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TENSILE TESTS OF GLASSES*

By W. L. Schwalbe, A. E. Badger, and W. B. Silverman

Abstract

A machine was designed to place tensile loads on glass fibers having diameters from 0.6 to 0.8 millimeter (0.024 to 0.032 inch). The results of tests on twelve glasses of known chemical compositions are given. The fractured surfaces exhibited characteristic smooth and rippled areas which were measured and correlated with the breaking loads. In order to compare the various glasses, it is convenient to use that value of the load per unit area which exists in a fiber whose fractured surface shows a smooth area that is 1% of the section. For the twelve glasses tested, these values ranged from 23.0 to 33.0 kg. per mm.^{2} (32,500 to 47,000 lb. per sq. in.) when the load on the fiber was increased at the rate of 1 pound per minute.

I. Introduction

The tensile strength of any material, whether it be a ductile substance like some metals or brittle like glass, is an experimental value which depends chiefly on (1) composition of the material, (2) size and shape of the test specimen, (3) rate at which the load is applied, (4) presence of flaws within the specimen and on its surface, and (5) sensitivity and accuracy of the testing machine. The conditions, therefore, must be defined under which the tensile strength is determined, and working values for the tensile strength of glass should be obtained from tests on commercial specimens. Thus, glass used for windows should be tested in the form of sheets, glass for bottles in that form, etc.

In studying the variation in tensile strength of glasses of different chemical compositions, however, the use of large specimens is not feasible because the glass melts must be made in platinum containers to avoid contamination of the glass by the solution of refractories. For such comparative tests of the tensile strength of glasses, the use of test specimens in the form of fibers has several advantages, *viz.*, only small amounts of glass are necessary, the test specimens may be drawn and shaped accurately, and a testing machine of sufficient capacity and suitable precision may be built readily.

A testing machine is described which was designed and built to stress glass fibers under tension, and the results of tests on glasses of various compositions are given.

* Received January 24, 1938.

Part of the expense of this project was defrayed by the Graduate School Fund of the University of Illinois in a grant to the Department of Ceramic Engineering, where the experimental work was performed. Publication is approved by the Engineering Experiment Station, University of Illinois.

II. Diameter of Test Specimen

The use of glass fibers as tensile specimens brings up the important effect of fiber diameter as shown by Griffith's data[1] in Fig. 1. An increase in diameter produces a tremendous decrease in the measured tensile strength, and this rate of decrease is much smaller for fibers with diameters of more than 0.010 inch.

In the tests given here, only those fibers were used whose diameters varied from 0.024 to 0.032 inch. These fibers are small enough that platinum-crucible melts provide sufficient glass, and they are large enough that small variations in their diameters produce negligible variations in the measurements of tensile strength.

III. Effect of Flaws in Test Specimens

Test specimens may contain interior flaws, such as bubbles and nonhomogeneous glass. Surface scratches, either visible or submicroscopic, caused by weathering, may be present, and these discontinuities cause localized stresses which result in uneven stress distribution when the specimen is placed under the tensile load.

Efforts were made to minimize these effects. As an aid to homogeneity, the glass was powdered and remelted. To produce specimens free from initial strain, the glass fibers were annealed. To prevent scratching of the surface, the necked-down section of the sample was not touched, and to minimize flaws from atmospheric weathering, the specimens were tested within an hour after their preparation.

IV. Preparation of Test Specimens

The specimens were prepared under controlled conditions. The platinum crucible containing

[1] A. A. Griffith, "Phenomena of Rupture and Flow in Solids," *Trans. Roy. Soc.* [London], **221A**, 163–98 (1920).

the homogeneous glass was transferred from the melting furnace to a small electric furnace into which a platinum bait could be lowered. A mechanical arrangement was used to raise the

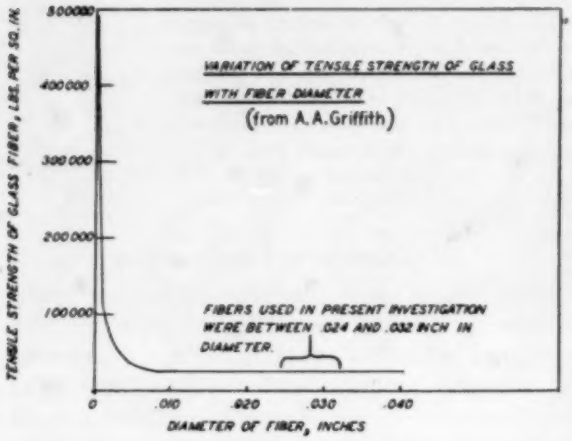

FIG. 1.

bait from the molten glass and to draw vertically a glass fiber about 1.5 millimeters in diameter to a length of about 6 feet. This fiber was broken into 3-inch segments.

Each segment was then placed in a vertical position, and the lower end was heated in a minute flame until a ball of glass formed which could be held in the chucks of the testing machine. The

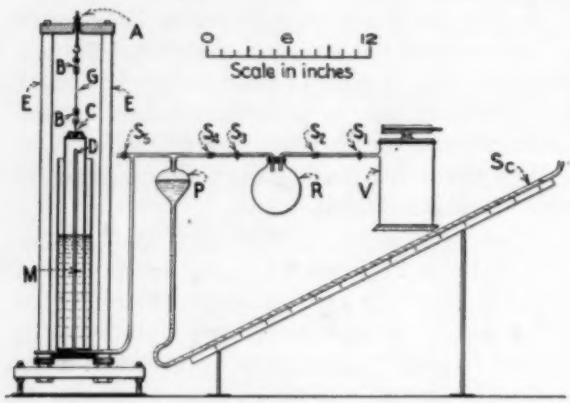

FIG. 2.

specimen with rounded ends was hung vertically in a small tube furnace, and the temperature was raised until a necked-down section having a diameter of 0.7 ± 0.1 millimeter was produced. The electric current was cut off, the specimen was annealed in its position, and with additional cooling it was ready for testing.

V. Design of Testing Machine

After deciding that fibers of about 0.7 millimeter (0.028 inch) were suitable for comparing the various glasses, a test machine was designed which would minimize bending stresses in the fiber from eccentric loading. This machine is shown in Figs. 2 and 3.

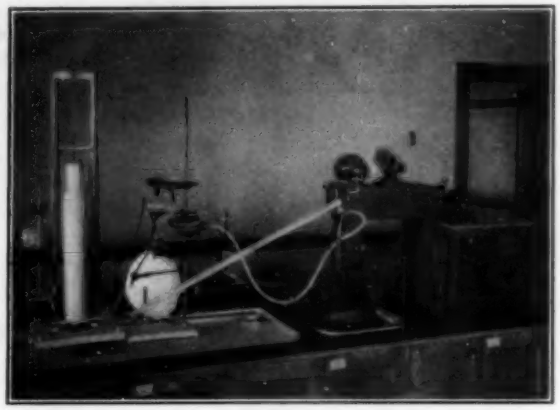

FIG. 3.

In Fig. 2, the glass fiber, *G*, is shown with a necked-down central section and with ball-shaped ends which fit into chucks *B*, *B*. The chucks are connected by small chains to ball-and-socket joints at *A* and *C*. The glass fiber is loaded by mercury, *M*, which is drawn into a freely swinging cylinder by a vacuum applied at *D*. A steel framework, *E*, supports the load. The rate of loading is controlled by the rate at which the vacuum is applied from the evacuated reservoir *R*, through the stop-cock, S_4. A vacuum pump, *V*, is used to evacuate the reservoir before starting a test. The rate of loading was maintained constant at about 1 pound per minute for all tests, the maximum load attainable being 30 pounds. A scale, *Sc*, indicated the vacuum existing in the space around *D*, from which the load was deduced by calibration of the apparatus. This calibration was carried out by substituting a lever for the test specimen, one end of the lever resting on a sensitive platform scale.

Figure 3 illustrates the test machine and the means of drawing the fibers. The mechanical drawing device and platinum bait are shown at the right in the photograph. At the left is the small electric furnace used to form the constriction or necked-down portion near the middle of the fiber to prepare it for testing.

VI. Appearance of Fracture

When glass fibers break under a tensile load, a characteristic fracture is observed; Fig. 4 illustrates some typical fractures as they appear under the microscope. The glass fiber breaks into three parts, the middle part being a wedge which flies out. The causes of this characteristic break are unknown. According to Smekal,[2] the break probably starts at some flaw in the surface, extends in a direction normal to the line of pull for a varying distance, and the whole fiber ruptures with the production of a rippled glass surface (Figs. 5*a* and 5*b*).

FIG. 4.

Similar effects are encountered at times in the rupture of metals. Figure 6 shows a fractured section of reinforcing steel rod (1 inch diameter).

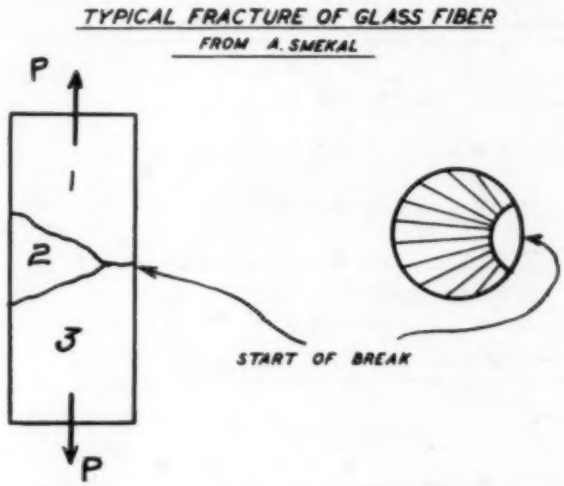

FIG. 5*a*. FIG. 5*b*.

X-ray diffraction patterns[3] of the two areas in Fig. 6 showed no difference in crystalline structure.

VII. Results of Tests

It was found experimentally that a fracture which had the appearance as in Fig. 4 (left) broke under a much greater load than that of the fractured specimen (right). These areas (small smooth area and total area) on all fractured specimens were measured under the microscope, and their ratios were plotted against the load per unit area in Fig. 7. Measurements are given for twelve commercial glasses, the chemical compositions of which are listed in Table I.

All curves in Fig. 7 are of the same type. The flat portions near the right correspond to low loads and large smooth areas. As the smooth area decreases, the load per unit area increases.

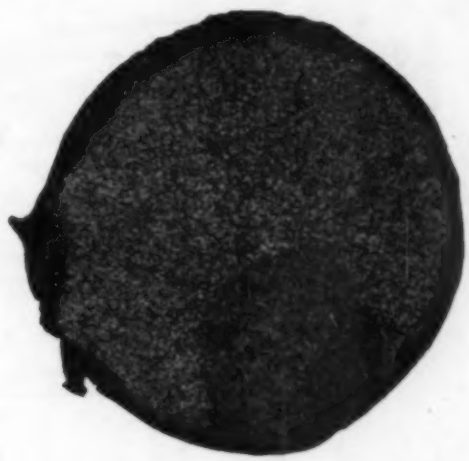

FIG. 6.

Extrapolation to a zero abscissa can not be made because the curves change slope too rapidly in this region.

The graphs shown in Fig. 7 may be straightened by plotting the logarithms of the ratios of areas instead of the actual ratios, as shown in Fig. 8. Extrapolation to zero gives the load necessary to break a specimen in which the smooth area is 1% of the total area of the section. It may be

[2] (*a*) A. Smekal, "Process of Rupture of Glasses," *Glastech. Ber.*, **13** [5] 141–51 (1934); *Ceram. Abs.*, **14** [10] 243 (1935).
(*b*) A. Smekal, "Effect of Structure in Decreasing the Strength of Glass," *Glastech. Ber.*, **13** [7] 222–32 (1935).
These articles also provide a summary of pertinent literature.

[3] By J. A. Pask in the Dept. of Chemistry, University of Illinois.

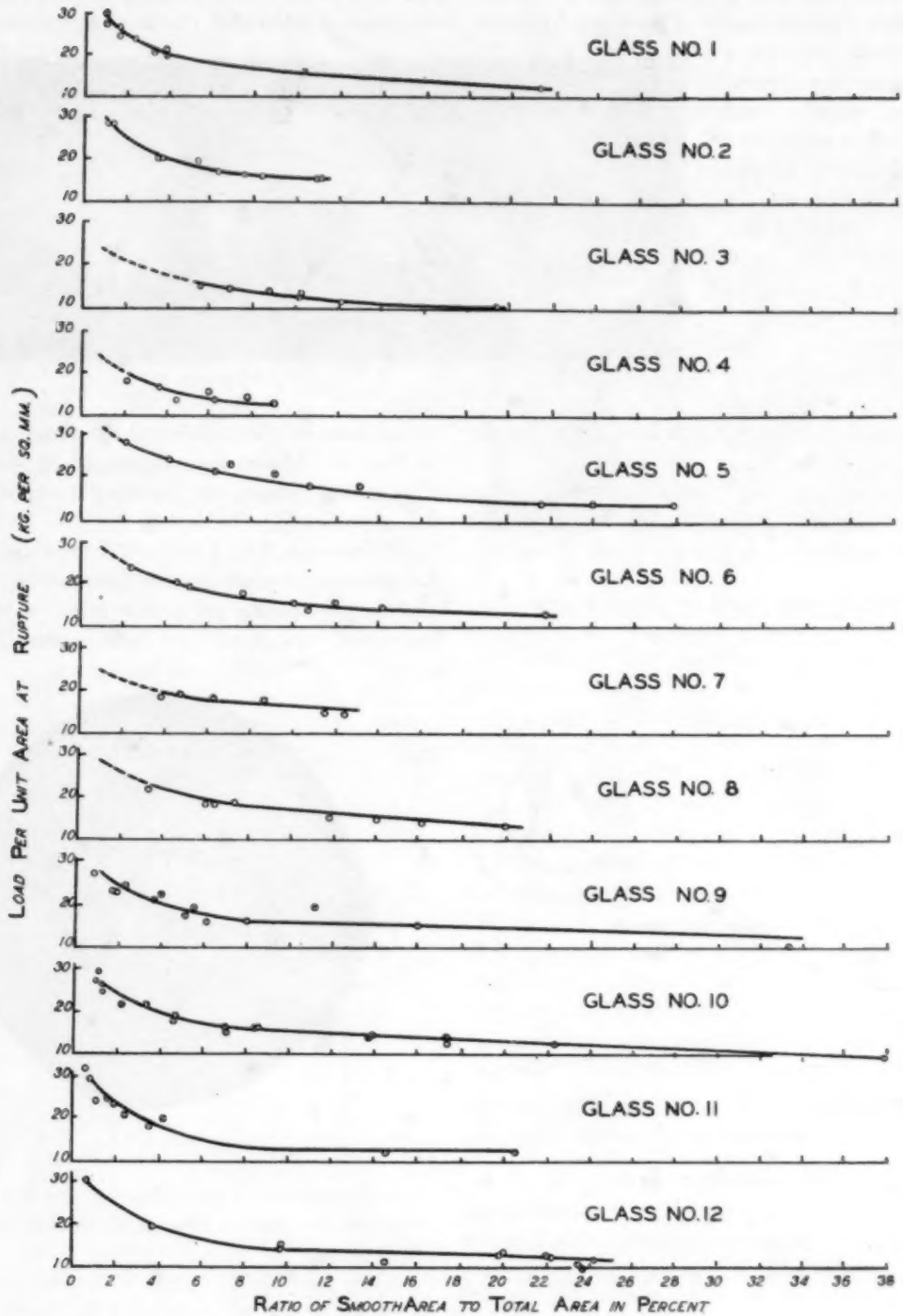
GLASS NO. 1
GLASS NO. 2
GLASS NO. 3
GLASS NO. 4
GLASS NO. 5
GLASS NO. 6
GLASS NO. 7
GLASS NO. 8
GLASS NO. 9
GLASS NO. 10
GLASS NO. 11
GLASS NO. 12
30
20
10
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38
LOAD PER UNIT AREA AT RUPTURE (KG. PER SQ. MM.)
RATIO OF SMOOTH AREA TO TOTAL AREA IN PERCENT

Fig. 7

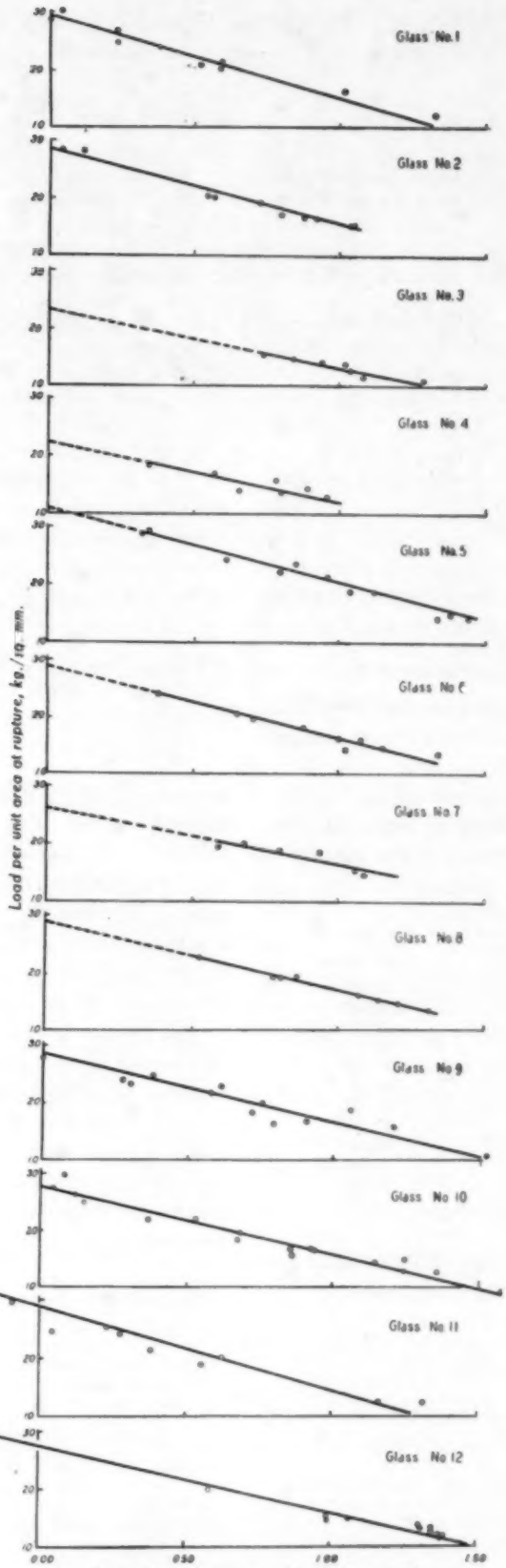
Glass No.1
Glass No.2
Glass No.3
Glass No.4
Glass No.5
Glass No.6
Glass No.7
Glass No.8
Glass No.9
Glass No.10
Glass No.11
Glass No.12
Load per unit area at rupture, kg./sq. mm.
0·00
0·50
1·00
1·50
Log (Ratio of smooth area to total area (per cent))

Fig. 8

TABLE I

CHEMICAL COMPOSITION OF GLASSES

Glass No.	1*	2	3†	4	5‡	6§	7‖	8‖	9‖	10‖	11‖	12‖
SiO_2	74.1	71.58	65.35	61.91	46.8	71.2	73.0	70.2	67.6	73.18	71.74	70.37
B_2O_3					19.0							
PbO			17.50	22.23								
Fe_2O_3	0.065	0.12	0.049	0.15								
Al_2O_3	0.33	0.54	0.18	1.00	5.0	2.5		3.8	7.4		1.96	3.83
CaO	4.65	12.94	0.21			9.3	5.8	5.6	5.4	7.77	7.62	7.48
MgO	3.23	0.10	0.03				4.2	4.1	3.9	3.02	2.97	2.90
K_2O	0.04		8.40	6.19	19.0							
Na_2O	16.65	14.00	5.70	8.32		17.0	17.0	16.3	15.7	16.02	15.71	15.41
SO_3	0.41		0.03									
As_2O_3	0.03		0.03	0.20 *ca.*								
As_2O_5	0.07		0.36									
Na_2SO_4		0.66										
NaCl		0.06										
Cl	0.047		0.05									
BaO			1.40									
TiO_2	0.02		0.01									
ZrO_2	0.003		0.005									
MnO	0.003		0.088		1.3							
P_2O_5			0.23									
CaF_2					7.9							
CoO					0.5							
NiO					0.5							
Ignition loss	0.30		0.32									
Total	99.948	100.00	99.972	100.00	100.00	100.00	100.00	100.00	100.00	99.99	100.00	99.99

* Bureau of Standards glass No. 80.
† Bureau of Standards glass No. 89.
‡ Computed from batch (sheet-iron ground coat No. 9 in A. I. Andrews, Enamels, p. 170. Twin City Pub. Co., Champaign, Ill., 1935).
§ Computed from batch by Bailey and Sharp Co., Hamburg, N. Y.
‖ Computed from batch.

observed that in some of the glasses (*e.g.*, No. 3) no fractures with small smooth areas were obtained, and consequently the accuracy of the extrapolation is reduced. The extrapolated values are listed in Table II. This table furnishes a comparison of the various glasses when tested in tension under the conditions summarized as follows: (1) diameter of fiber (0.6 to 0.8 mm.) (0.024 to 0.032 inch), (2) rate of loading (1 lb. per min.), (3) ratio of smooth area to total area of fracture (0.01), and (4) fibers to be cooled slowly in furnace after necking-down operation and tested about 1 hour after removal from furnace.

TABLE II

Glass No.	Load per unit area on section (kg. per mm.²)	(lb. per sq. in.)
1	29.5	42,000
2	28.0	40,000
3	23.0	33,000
4	23.5	33,500
5	33.0	47,000
6	28.5	41,000
7	26.0	37,000
8	28.5	40,500
9	28.5	40,500
10	27.5	39,000
11	29.0	41,000
12	29.0	41,000

The results indicate that a reliable comparison of various glasses may be obtained from a small number of individual measurements. The data do not represent the actual tensile strength of glass because the distribution of stress over the section is unknown, and concentrations of stress caused by imperfections in the specimens and in the testing machine were not determined.

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MEASUREMENT OF SURFACE TENSION OF VISCOUS LIQUIDS*

By C. A. Bradley, Jr.

Abstract

The surface tensions of liquids of widely differing viscosities have been measured by the maximum bubble-pressure method. With liquids whose viscosities are greater than about five poises, a modification of the customary technique is employed, which consists in observing the maximum pressure at which a bubble is stable. This is the same procedure which Parmelee used. The applicability of this method for viscous liquids has been tested by measuring the surface tensions at 25°C of a series of solutions of rosin in benzyl-benzoate whose viscosities varied from about 100 to 2500 poises. The values obtained are within 1% of those observed by the method of capillary rise. The method has been applied to the measurement of the surface tensions of molten glasses whose viscosities varied from 50 to 2500 poises. The precision obtained is about 1%. A technique for the approximate measurement of surface tension of glasses by means of sessile drops is described.

I. Introduction

The problems involved in the measurement of the surface tensions of molten glasses are those common to all viscous liquids, but in addition there is the difficulty that the determination on glasses must be made at high temperatures. A number of methods have been tried on molten silicate glasses, but the results obtained differ so widely that their reliability may be reasonably doubted. The recent work of Parmelee[1] and his co-workers has indicated that the maximum bubble-pressure method can be successfully applied to viscous liquids including molten silicate glasses.

It was decided to test this method further by using it to measure the surface tensions of a series of liquids whose viscosities near 25°C would be comparable to those of molten silicate glasses over a considerable range of temperature. The surface tensions of the same liquids would be determined by the method of capillary rise. If the results by the two methods agreed satisfactorily, it was believed that the maximum bubble-pressure method could be used with considerable certainty on molten glasses. The present paper describes these experiments.

While the bubble-pressure method is perhaps the most accurate which can be applied to molten glasses, it was thought that the sessile-drop method might be used with fair accuracy at lower temperatures. This has been found to be the case, and the experimental work is described in the latter part of this paper.

II. Maximum Bubble-Pressure Method

This method consists in measuring the excess pressure above atmospheric necessary to cause a bubble to break from the end of a capillary tube immersed in the liquid whose surface tension is to be determined. If the end of the tube from which the bubble is blown rests exactly in the surface of the liquid, the pressure observed is entirely that necessary to overcome surface-tension forces, and no correction due to hydrostatic head is necessary. The theory of the method has been worked out by Schrödinger[2] and Vershaffelt.[3] The former gives a more convenient expression and it was the one used in the present work. It is as follows:

$$T = P\frac{r}{2}\left(1 - \frac{2}{3}\left(\frac{r}{h}\right) - \frac{1}{6}\left(\frac{r}{h}\right)^2\right)$$

Where T = surface tension (dynes/cm.)
P = maximum excess pressure observed (dynes/sq. cm.), *i.e.*, excess pressure in bubble at end of capillary over pressure at same level in surrounding liquid
r = radius of capillary (cm.)
$h = \frac{P}{(d_1 - d_2)g}$ (where d_1 = density of liquid)
d_2 = density of gas in bubble
g = gravitational constant.

This equation assumes that a static condition exists and that the bubble is hemispherical with

* Presented at the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 29, 1938 (Glass Division). Received March 30, 1938.

[1] (*a*) C. W. Parmelee and K. C. Lyon, "Maximum Bubble Pressure (Jaeger) Method for Measurement of Surface Tension of Molten Glass," *Jour. Soc. Glass Tech.*, **21**, 44–52 (1937); *Ceram. Abs.*, **17** [8] 275 (1938).
(*b*) C. W. Parmelee and C. G. Harman, "Effect of Alumina on Surface Tension of Molten Glass," *Jour. Amer. Ceram. Soc.*, **20** [7] 224–30 (1937).
(*c*) A. E. Badger, C. W. Parmelee, and A. E. Williams, "Surface Tension of Molten Glass," *ibid.*, **20** [10] 325–29 (1937).

[2] E. Schrödinger, "Capillary Pressure in Gas Bubbles," *Ann. Physik*, [4] **46**, 413 (1915).

[3] J. E. Vershaffelt, "Shape of Small Drops and Gas Bubbles," *Proc. Acad. Sci. Amsterdam*, **21**, 357–65 (1919).

a radius equal to that of the capillary opening. It is clear that when these conditions are met the pressure will be a maximum. For liquids of high surface tension or for very small capillaries, the second and third terms in the parentheses (which depend upon the density of the liquid) will be small. The surface tensions of most silicate glasses probably range from 250 to 350 dynes per centimeter. With a capillary 0.05 centimeter in radius, the second term would then contribute about 1% to the total, and the third term is entirely negligible. Thus, the density of the glass could be estimated to about 10%, and the value of the surface tension would be affected only by $\pm 0.1\%$. Therefore the measurement of the surface tension depends essentially upon the rather easily made determination of the pressure and the capillary radius.

The method is easy to use with liquids whose viscosity is about five poises or less. The capillary, connected to a source of air and a manometer, is set in the surface of the liquid, and air is allowed to bubble through at a rate of one bubble per second or more slowly. The maximum pressure is observed directly. For liquids of higher viscosity, such a technique can not be used because the observed pressure will always be higher than the true maximum, inasmuch as the viscosity of the liquid opposes the blowing of the bubble. Parmelee,[1] however, has worked out a technique which seems to be satisfactory for use with liquids of higher viscosity, and it was the one found to be the most practical in the present work. The logic behind the technique may be explained as follows: At any pressure below the true maximum, the bubble will be stable; at any pressure above the true maximum, the bubble will be unstable and will break. How quickly the bubble will break will depend on the viscosity of the liquid and on the pressure above the stable maximum. Thus, if pressure is applied until the bubble does break, it is known that the true maximum pressure at which the bubble will be stable is smaller. If further bubbles are blown at successively reduced pressures, one pressure will be found at which the bubble will not break but will break at any higher pressure. This, within the limits of accuracy of the measurement of the pressure and the difference between successive steps, will be the true maximum.

In this procedure, the pressure difference which causes the bubble to burst is smaller for each successive bubble. Therefore the length of time between the application of the pressure and the breaking of the bubble will increase as the true maximum pressure is approached. It is necessary, then, to maintain the chosen pressures constant for a time long enough for the bubble to break or to be sure equilibrium has been established. If the viscosity is about 800 poises or less, ten to fifteen minutes is ample time.

It also must be made certain that the liquid does not enter the capillary. If this happens, it may (depending upon the viscosity) take a much longer time than ten minutes to expel the liquid from the capillary. In addition, the film of liquid on the walls of the capillary may cause the radius of the bubble to be different from the radius of the capillary.

III. Experimental

The test liquids used in this work were water, benzene, glycerine, and solutions of rosin in benzyl-benzoate. The latter were similar to those used by Washburn and Libman[4] in their

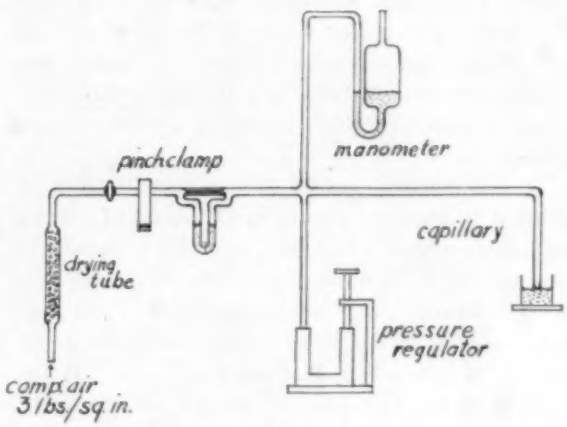

FIG. 1.

experiments on the determination of surface tensions by the dipping-cylinder method. The viscosities of the liquids were from about 50 to 2500 poises at 25°C.

The bubble-pressure apparatus may be most conveniently described by the schematic diagram in Fig. 1. The flow regulator consisted of a piece of rubber pressure tubing in a pinch clamp

[4] E. W. Washburn and E. E. Libman, "Viscosities and Surface Tensions of Soda-Lime Glasses at High Temperatures: II," *Univ. of Ill. Eng. Expt. Sta. Bull.*, No. 140, pp. 53–71 (1924); *Ceram. Abs.*, **3** [12] 342–44 (1924).

with a long lever arm. The manometer was a U-tube; the ratio of the areas of the arms was 100 to 1. The tubes were carefully selected for uniformity of bore, and the diameter of the small tube was 10.0 millimeters. The manometric fluid was *N*-dibutyl-phthalate. The manometer was thermostated at 25°C, and the pressures were measured by determining the heights of the liquid in the small arm by means of a cathetometer, whose scale is accurate to ±0.05 millimeter. These heights were subtracted from the level in the small arm when the pressure in the apparatus was atmospheric. This difference was then multiplied by 1.01 to allow for lowering the level in the wide tube. After a surface tension measurement was completed, the level at atmospheric pressure was always redetermined. Usually the readings before and after agreed to ±0.05 millimeter; the greatest difference ever observed was 0.10 millimeter.

The pressure regulator was a steel U-tube of 0.75 inch inside diameter, half-filled with mercury. One arm was connected to the system. In the other arm was a steel plunger connected to a threaded shaft which passed through a fixed nut. The pressure in the apparatus could be changed over small limits by raising or lowering the plunger. The final pressure adjustments were always made with this regulator.

The capillaries used in these test experiments were made of glass, carefully selected for circularity of bore. Five were used for most of the work, and these had the following diameters: *A*, 0.591 mm.; *B*, 0.744 mm.; *C*, 0.820 mm.; *D*, 0.874 mm.; and *E*, 0.944 mm. Short sections were sealed to pieces of 8-mm. tubing, and the capillary ends were ground off until examination showed the circumference of the bore to be free from faults. Some measurements were made with the capillaries tapered at the end; others were made where the end was blunt, but the bore of the capillary was enlarged rapidly going up the tube. Equally reliable values of the maximum pressures were obtained, using capillaries with any of these shapes. It was found, however, that the viscous liquids could more easily be kept from entering a tube of the last-described design. In addition, it was found that capillaries with blunt ends could be set more accurately in the liquid surface than tapered capillaries when one could not directly observe the contact of the tube with the surface.

Slight ellipticity of the capillary opening does not influence the maximum pressure materially, nor does an inclination of three or four degrees of the plane of the opening from horizontal. It was found important, however, that the circumference of the opening be free from faults of any kind, especially cracks or fissures.

The radii of the capillaries were determined by averaging four measurements on each of four diameters made with a micrometer slide whose screw was good to 0.002 millimeter. Individual measurements on any diameter never differed by more than 0.010 millimeter, and any one measurement never differed from the average of four by more than 0.005 millimeter. For any one capillary, the greatest difference among the averages for the four diameters was 0.016 millimeter, and the greatest average deviation was ±0.006 millimeter. With a capillary of about one millimeter in diameter, this amounts to an uncertainty of about 0.6%, which will be correspondingly greater for capillaries of smaller diameter. The error introduced into the value for the surface tension by the uncertainty in the measurement of the capillary radius is usually much larger than that caused by errors in the value for the maximum pressure. This is especially true if the surface tension is large.

Sections of three of the capillaries, *A*, *B*, and *C*, were found to be of uniform bore. The average diameters of the sections were determined by weighing measured lengths of mercury contained in the capillaries. These tubes were used for the capillary-rise determinations on the benzoate solutions. The wide tube containing the liquid had a diameter of 7.5 centimeters. The equilibrium height of rise was approached with a falling meniscus. The solutions were pulled up into the capillary beyond the maximum height, and the level of the meniscus was observed periodically until no further falling was seen.

All of the experiments by both methods were carried out in a water thermostat at 25 ± 0.05°C.

Table I contains the values obtained by the two methods. Individual measurements by the bubble-pressure method on the same liquid with the same capillary differed by less than 1%. The table shows that the values obtained by the two methods differ by no more than the precision of either method. It was believed, therefore, that the method was a reliable one to use with molten glasses.

TABLE I

Cap.	r (cm.)	Surface tension (dynes/cm.) H_2O		C_6H_6		$C_3H_8O_3$		64.3% rosin		66.7% rosin		75% rosin	
		CR	BP	CR	BP	CR	BP	CR	BP	CR	BP	CR	BP
A	0.0296		72.09		28.16		63.26	38.33	38.53	38.33	38.69	39.22	38.07
B	.0372		71.67		27.86		63.20	38.76	38.12	37.60	38.12	38.58	38.19
C	.0410		71.80		27.77		63.75	38.13	38.04	38.29	38.25		38.04
D	.0437		71.52		27.89		63.23				37.79		38.24
E	.0452		71.74		28.10		63.04		38.73		37.80		38.15
F	.0488	72.03		27.90		63.13							
Platinum	.0497		72.28				64.50				38.25		
Av.			71.91		27.96		63.38	38.41	38.31	38.07	38.13	38.90	38.14
A.d.			0.24		0.14		0.20	0.27	0.25	0.32	0.25	0.32	0.25

CR = measurement by capillary-rise method.
BP = measurement by bubble-pressure method.

IV. Measurements on Molten Glasses

The only significant changes made in the apparatus for the determinations on molten glasses were in the capillary and its support. The design of the capillary is shown in Fig. 2. The short length of platinum tubing was connected inside the furnace to the sillimanite tubes to minimize the rapid conduction of heat by the platinum from the glass. The sillimanite tubes, *C* and *D*, were 2 millimeters in wall thickness and of 8 and 12 millimeters outside diameter, respectively. The lower end of tube *C* was tapered to fit into the 60° platinum cup of the capillary. Part *A* of the brass lock nut was pinched onto tube *C* by means of two screws. When assembled, and nut *B* was tightened at room temperature, the joint between the capillary and tube *C* was gas-tight at all temperatures and pressures attained. The upper part of tube *C* was connected to an arm, which allowed adjustment of the capillary in any direction and which could be raised and lowered on a rigid, vertical steel shaft. A micrometer head was mounted on the shaft so that when the capillary was lowered into the furnace, the head supported the arm when the end of the capillary was a few millimeters above the glass surface. From this position, the capillary could be lowered to the glass surface in as small increments as desired. Connection of tube *C* to the air supply and manometer was made by rubber pressure tubing.

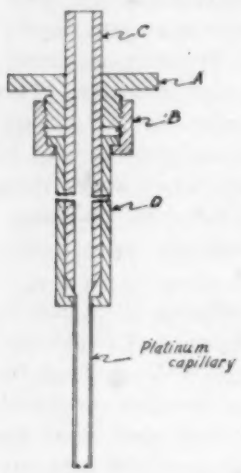

FIG. 2.

The furnace used in these experiments was a platinum-wound tubular furnace, mounted vertically and regulated by a Leeds and Northrup micromax controller. An insulating cap extending three inches into the furnace, with a hole just large enough for tube *D* (Fig. 2) to pass through, was used for a cover. The cap also supported a Pt-Pt Rh thermocouple for recording the temperatures at which the measurements were made. The platinum crucible rested on a pedestal so that the glass level was approximately at the center of the furnace.

In carrying out the experiments, the capillary was located in the surface of the glass by the same procedure as described by Parmelee.[1] It is believed that the error in locating the capillary in the surface was 0.1 to 0.2 millimeter. This would cause an error of about 0.2 to 0.4 millimeter of butyl phthalate in the observed pressure. After the capillary was located in the glass surface, a bubble was formed and the pressure was increased slowly until the bubble broke. If the viscosity of the glass was about 100 poises or less, this breaking pressure would be only a few millimeters above the true maximum. Bubbles were then blown, usually at successive 0.2-millimeter lower pressures, until one was reached at which the bubble would not break in ten or fifteen minutes but would burst (usually within 1 or 2 minutes) when pressure was then increased by 0.2 millimeter. In some of the determinations, the successively applied pressures differed by 0.1 millimeter. With the more viscous glasses (500 poises or greater), 0.5-millimeter pressure differences were used. Because the pressures ranged from about 90 to 130 millimeters, the uncertainty in the pressure was always less than 1%. Furthermore, with the more

viscous glasses, the maximum pressure was held constant for thirty minutes or more.

It is important that the capillary should be accurately centered with the glass surface. In these experiments, a correction of about 0.5 dyne per centimeter should be added to the values for the surface tension caused by the curvature of the glass surface in the crucible. This was not done because this correction is considerably smaller than the precision of the determinations.

The glasses studied were, for the most part, melted from finely ground batch in the platinum crucible and heated for about four hours at 1450° to 1500°C. The surface-tension measurements were then made. Some of the samples, including the Bureau of Standards' glasses, were melted from cullet.

$$\frac{\beta^2}{r^2} = \frac{\frac{1}{2}\frac{h^2}{r^2}}{\left(1 - \frac{h^2}{r^2}\right) + \Delta_2}.$$

Where

$\beta^2 = \dfrac{\text{surface tension (dynes/cm.)}}{\text{density} \times \text{gravitational constant}}$

h = height (cm.) of drop above maximum cross-section

r = radius (cm.) of maximum cross-section.

It is advisable to choose the size of the drop so that the correction term is not near its maximum or minimum values. For ordinary silicate glasses, r equal to about 7 to 8 mm. with h consequently 4.5 to 5.0 mm. is a convenient size.

TABLE II

	Glass No.									
	1a	1b	1c	1d	1a	1b	2	3	3	3
Temp. (°C)	1353	1375	1389	1406	1250	1260	1477	1487	1387	1277
Surface tension (dynes/cm.)	318	312	312	305	319	315	341	353	344	342
Approximate viscosity (poises)	200	175	160	150	500	500	1000	75	150	2500
Remarks	Soda-lime glass; cullet	Soda-lime glasses melted from batch					Boro-silicate glass; cullet	Calcium-aluminum silicate glass; cullet		

	Glass No.									
	7	7	7	8	8	8	8	9	9	9
Temp. (°C)	1488	1396	1277	1289	1396	1500	1483	1500	1395	1288
Surface tension (dynes/cm.)	302	303	304	242	244	244	246*	303	305	306
Remarks	N.B.S. glass No. 80	Soda-lime glass		N.B.S. glass No. 89	Lead-barium glass			N.B.S. glass No. 92		Low boron glass
Parmelee's† values at 1350°C		302			245				299	

* Obtained after heating five hours longer at 1500°C.
† See C. W. Parmelee, footnote reference 1.

Table II gives the results of some typical determinations. The surface tensions of the Bureau of Standards' glasses have also been measured by Parmelee,[1] and the agreement between his values and those reported here appears to be quite good.

V. Experiments with Sessile Drops

Porter,[5] using Bashforth and Adams' tables and Rayleigh's formulas for the shape of sessile drops, has worked out a simple expression and tabulated the correction term by which the surface tension may be calculated from the dimensions of sessile drops. His formula is

A disadvantage of the method is that the density of the glass must be known at the temperature of the determination, which limits the accuracy of the method. In the present work, an estimate of the density was made from its value at room temperature, and consequently the values of the surface tension are not considered to be accurate closer than ±8%. The determinations were made at about 1000°C.

The procedure found most satisfactory may be described as follows: A thin platinum plate was coated with a slurry of silica flour and dried. It was found that the glass did not wet this coating as well as it wetted platinum. A piece of glass of about the most favorable size was put on the plate, which was then placed in a small furnace at 1000°C and left for a few minutes. The length of time necessary for the drop to assume its equilibrium shape depends on the viscosity of the glass at the temperature of the determination. The time required for this was found by removing

[5] A. W. Porter, "Calculation of Surface Tension from Experiments: I, Sessile Drops," *Phil. Mag.*, [7] **15,** 163–70 (1933); [7] **20,** 703 (1936).

the drop at intervals of from five to ten minutes, measuring the height and maximum diameter with a micrometer slide, and reheating for another period. This procedure was repeated until no further changes in the dimensions were observed. Quite irregularly shaped pieces would pull themselves into symmetrical shapes so that the section of maximum diameter was circular.

The calculation of the surface tension is quite sensitive to errors in the measurement of h, and this dimension can be measured less accurately than r. An error of about 1% in h affects the value for the surface tension by about 3%; an error of 1% in r affects the surface tension only a few tenths of 1%.

TABLE III

	Glass No.			
	1a	4	5	6
(I) Surface tension (dynes/cm.)	294	320	329	360
(II) Surface tension (dynes/cm.)	322	335	347	368
		B_2O_3	B_2O_3	B_2O_3
Surface tension (dynes/cm.)		66.9	62.1	57.0
Temp. (°C)		500	400	300

(I) = values obtained by sessile-drop method.
(II) = values by extrapolation of bubble-pressure results.

Table III gives the results of some typical measurements compared with the values obtained by extrapolating to 1000°C the results observed by the bubble-pressure method at higher temperatures. The values of some measurements by the sessile-drop method on boric oxide glass are also given.

VI. Conclusion

It is believed that the work reported here shows that the maximum bubble-pressure method can be used to determine the surface tension of molten glasses with an accuracy about equal to the precision of the measurements, which is about 1%. For individual measurements using the same capillary, the precision is considerably better. It is assumed that the glasses are well mixed and that their composition does not change upon heating to high temperatures. In this case, the precision is a function only of locating the capillary in the glass surface and the precision of the pressure determination.

For rapid approximate surface-tension measurements on small samples of glasses, the sessile-drop method can be used and requires little equipment.

Acknowledgment

The writer would like to express his appreciation to G. V. McCauley, who suggested this investigation, for much helpful discussion.

CORNING GLASS WORKS
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EFFECT OF GLASS COLOR ON SETTING RATES IN MANUFACTURE OF GLASS BOTTLES*

By O. G. Burch and C. L. Babcock

Abstract

It has been observed in the manufacture of bottles of the same size and shape from various colored glasses, such as emerald green and amber and the so-called flint bottle glass, that higher machine speeds are usually obtained in the case of the colored glasses. A laboratory test has been devised to measure the cooling rates of several colored and colorless glasses throughout their respective working ranges, which gives results paralleling the speeds obtained in actual bottle manufacture.

I. Introduction

It has been customary for investigators. to express the working range of a particular glass composition in a given fabricating process as the rate of change of viscosity with temperature between those temperatures which are considered to be the upper and lower working limits of the glass for the particular operation. There is little, if any, information in the literature pertaining to the actual temperature limits of working in any glass-fabricating process.

Following the second joint meeting of the Technical Committees of the Deutsche Glastechnische Gesellschaft and the Society of Glass Technology, held in London in June, 1930, a recommendation was made and adopted for expressing the limits of the working range of a glass with respect to the viscosity of the glass.[1] The temperature, corresponding with the viscosity of 10^3 c.g.s. units, was regarded as the upper working temperature; the temperature at which the viscosity is 10^6 c.g.s. units was regarded as the temperature of the lower limit of the working range.

II. Working Range Temperature of Glass

The working range of a glass is usually expressed as the temperature interval between those temperatures at which its log viscosity is equal to 3.0 and 6.0, respectively. If such a limit is not qualified, however, erroneous conclusions may be drawn; *i.e.*, suppose that for two glasses, A and B, of different chemical compositions, the temperatures necessary to obtain a log viscosity equivalent to 3.0 were 2200° and 2000°F, respectively. Suppose, furthermore, that for these same glasses the necessary temperatures to obtain log viscosities equivalent to 6.0 were 1600° and 1400°F, respectively. Insofar as the temperature interval between the upper and lower working limits of both of these glasses is concerned, the values are identical, *viz.*, 600°F. To an observer it is obvious, however, that, in any glass-fabricating process, less time would be available for lowering the temperature of glass A from 2200° to 1600° than would be available for lowering the temperature of glass B from 2000° to 1400°. Glass A would thus be considered to have a shorter working range. This fact has previously been mentioned by English[2] and by Kitaigorodskiĭ and Solomin.[3] The latter, in addition to stating that the setting rates of colorless glasses were dependent upon the upper and lower temperature limits of the working range, also stated that other factors involved were the thermal conductivity and heat capacity of the glasses, the size and form of the article being fabricated, the temperature of the mold surface, and the thermal properties of the material and surface of the mold.

To the writers' knowledge, English and Turner[4] were the first investigators to notice that dark-colored glasses have shorter working ranges or faster setting rates than colorless glasses, even though the rates of change in viscosity with temperature for the two types of glass may be identical. Their conclusions were based on actual hand-working tests of the two types of glass in the form of rods and tubes, and upon measurements made on rates of cooling of a colorless soda-lime glass and a glass of the same basic composition

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[1] "International Glass Standards," *Jour. Soc. Glass Tech.*, **14**, 159 (1930).

[2] S. English, "Effect of Various Constituents on the Viscosity of Glass near Its Annealing Temperature," *Jour. Soc. Glass Tech.*, **7** [25] 25–45 (1923); *Ceram. Abs.*, **2** [12] 276 (1923).

[3] I. I. Kitaigorodskiĭ and N. W. Solomin, "Rate of Setting of Glass during Working," *Jour. Soc. Glass Tech.*, **18** [72] 323–35 (1934); *Ceram. Abs.*, **14** [8] 187 (1935).

[4] S. English and W. E. S. Turner, "Study of Casing of Colorless by Cobalt Blue Glass: II, Question of Setting Rate," *Jour. Soc. Glass Tech.*, **12**, 75–82 (1928).

colored by the addition of cobalt oxide throughout a given temperature interval, the temperature measurements being made both at the surfaces and one inch below the surfaces of the two glasses. They concluded that the faster setting rate of cobalt blue glass was due to its greater radiating power, whereby the fall of temperature of the outer layer, and subsequently the increase in viscosity of this layer, are greater than with colorless glass.

Kitaigorodskiĭ and Solomin[3] also studied the cooling rates of colored and colorless glasses of the same basic composition throughout a definite temperature interval, and they found that at or near the surface, glasses colored by the addition of cobalt oxide, ferrous oxide, or ferric oxide cooled considerably faster than did a colorless glass of the same basic composition. They concluded from their investigation that the addition of coloring substances which produce an absorption of infra-red rays with wave-lengths within the range 1 μ to 4 μ causes a considerable increase in the cooling rate of the outer layers, with a decreased rate of cooling, and hence of setting, of the inner layers of the glass. The first part of their conclusions seems to be borne out by their experimental data, but the same data do not bear out the second part of their conclusion for glasses colored by ferric oxide.

Several years ago it was called to the attention of the writers that, in the manufacture of relatively large glass bottles of the same size and shape (capacities 26 to 32 ounces; weights 26 to 28 ounces) on a 10-arm Owens machine, using single cavity molds, in both emerald green and so-called flint bottle glass, greater speeds were always obtained with the green glass. For example, over a period of a year in manufacturing this type of ware in the described operation, flint bottles were produced at the rate of 23.5 bottles per minute and emerald green at the rate of 27.0 bottles per minute. The limiting factor in the speed obtainable with the flint glass was the tendency of flint bottles to go out of shape if run at speeds comparable to those used with green glass. This fact led to the conclusion that for some reason the green glass was cooling more rapidly than the flint glass.

The same phenomenon seemed borne out to some extent in the manufacture of bottles of identical sizes and shapes on flow machines when operating in flint and amber glass. For instance, in such operation, the average speeds obtained over a period of one year in operating three jobs varying in capacity from 16 to 32 ounces and in weight from 14 to 28 ounces, were, respectively, 20.8 bottles per minute in amber glass and 19.9 bottles per minute in flint glass.

The present writers believe that the rate of change of viscosity of the surface of the glass was the controlling factor in the speeds at which bottles could be fabricated, and further, that apparently owing to a faster cooling rate, the surfaces

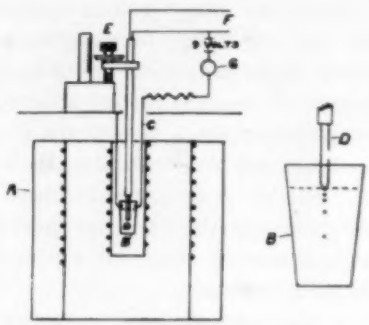

FIG. 1.—Cooling rate apparatus.

of the dark-colored glasses were losing heat faster and therefore setting up more quickly than the surface of the flint glass. In order to check this reasoning, the apparatus shown in Fig. 1 was devised. This setup is somewhat similar to that employed by Kitaigorodskiĭ and Solomin.[3]

III. Test Apparatus

The furnace, *A*, is a platinum-wound resistance furnace 12 inches high, with a bore two inches in diameter. The furnace is closed at the bottom and so mounted that it can be raised and lowered on vertical standards. The platinum crucible, *B* (the container for the molten glass), is a truncated cone 5 centimeters high, 3.2 centimeters in diameter at the top, and 2.2 centimeters in diameter at the bottom. This crucible is suspended in an upright position in the furnace by two platinum wires, *C*. The amount of glass used for a determination is 55 grams; the glass has an approximate specific gravity of 2.4. This quantity of glass, when seed-free, at a temperature of 2200°F, makes the top surface of the glass approximately 1 centimeter below the top of the crucible. The area of exposed glass surface is thus approximately 17% of the total glass surface area.

Temperatures are measured by means of a platinum-platinum rhodium thermocouple, *D*, with a bead as nearly as possible 1 millimeter in diameter. The thermocouple, *D*, is mounted in a clamp on a micrometer screw, *E*. Temperatures are measured by a portable Leeds & Northrup potentiometer, *F*.

IV. Test Procedure

The procedure in making a determination is to weigh out 55 grams of crushed glass of the composition to be studied, to place a portion of this weighed sample in the suspended platinum alloy crucible, to raise the furnace to its upper position, and to heat until the portion of the glass contained in the crucible is seed-free. This process is repeated, adding various portions of the weighed sample until the entire 55 grams have been added and are in a seed-free condition. The thermocouple is then lowered until the bead is approximately $^1/_8$ inch above the surface of the molten glass and the couple is lined up so that the bead is as nearly as possible in the center of the cross-sectional area of the glass surface. The furnace is then raised and the glass is heated until the temperature registered by the thermocouple is slightly above the temperature at which it is desired to make the determination. An external voltage of approximately 9 volts is then impressed upon a circuit in which the thermocouple is one pole and one of the suspension wires, *C*, the other pole. A milliammeter, *G*, is placed in this external circuit. The thermocouple, *D*, is then lowered by the micrometer screw, *E*, until an abrupt deflection is observed on the milliammeter. The external circuit is then broken, the micrometer screw reading is recorded, and the thermocouple is lowered by this screw, *E*, until the apparent depth of the lowest portion of the bead is 20 millimeters below the surface of the glass. Lowering the thermocouple will cause some displacement of glass, slightly raising the level of the glass in the crucible. Inasmuch as this raising of the level is constant for any two determinations at equal depths, the results are negligible. The heating is continued until the temperature at the depth of 20 millimeters remains constant at 125°F above the upper temperature from which the cooling rate is to be determined. The thermocouple is then raised 19 millimeters by means of the micrometer screw. This makes the lowest surface of the thermocouple bead immersed 1 millimeter in the glass. The temperature as indicated by the thermocouple is then noted. (Unfortunately, the furnace was so constructed that a temperature gradient existed throughout the height of the crucible. At temperatures near 2200° to 2300°F, the temperature of the glass 20 mm. below the surface is approximately 35°F greater than the temperature 1 mm. below the surface.) The furnace is then lowered to its extreme lower position and covered. This leaves the hot crucible suspended in air. In the meantime, the potentiometer has been set to correspond to the temperature for the upper limit in the determination. The interval, from the instant the furnace is lowered until the temperature of the glass 1 millimeter below the surface corresponds to that of the setting of the potentiometer, is measured by a stop watch. Temperature readings are then taken at 15-second intervals until the temperature indicated is slightly lower than that corresponding to the fiber softening point of the glass as defined by Littleton.[5] The furnace is

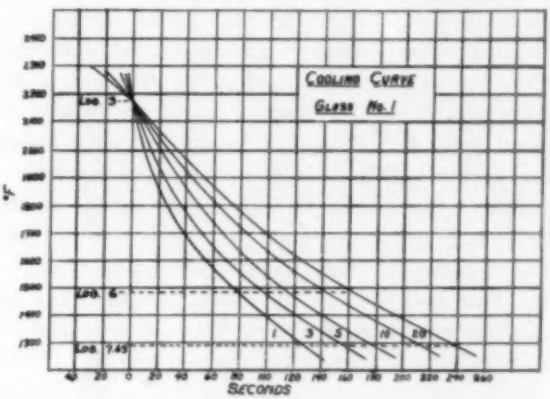

FIG. 2.

then uncovered and raised to its upper position, and the glass is reheated until the temperature is the same as at the time of lowering the furnace. The thermocouple is then again lowered to the 20-millimeter depth, and the furnace again is brought to temperature equilibrium 125°F above that of the upper limit used for the determinations being measured. The thermocouple is raised until its lower surface is 3 millimeters below the upper surface of the glass; this temperature is recorded, the furnace is lowered, and the proce-

[5] J. T. Littleton, Jr., "Method for Measuring Softening Temperature of Glasses," *Jour. Amer. Ceram. Soc.*, **10** [4] 259–64 (1927).

dure is repeated as at the 1-millimeter depth. This process is continued until cooling curves have been obtained at depths of 1, 3, 5, 10, and 20 millimeters. Examples of such cooling curves will be referred to later.

The question now arises as to the temperature interval through which cooling rates are to be measured. This interval should correspond as nearly as possible to that existing in the actual bottle-fabrication processes. To establish the upper working limit, temperature measurements were made by a bare Pt-Pt Rh thermocouple in the revolving pot used in Owens machine operation. The point of temperature measurement in this pot was as near as possible to that at which the blank mold initially came in contact with the glass surface. On a variety of jobs, varying in capacity from 1 to 132 ounces and in weight from 2 to 60 ounces, these temperatures were found to vary from 2290° to 2000°F. For the particular glasses on which the measurements were made, the log viscosities corresponding to these two temperature extremes are 2.72 and 3.50. It was thus obvious that an average glass viscosity at the upper limit of the working range in Owens machine operation must be close to 10^3 c.g.s. units. As a matter of fact, for the particular relatively large jobs, *i.e.*, 26- to 32-ounce capacity previously referred to in Owens machine operation, actual temperature measurements made in the revolving pot on several occasions showed the log viscosity to vary from 2.91 to 3.08 both for the flint and the emerald green glasses. The establishment of the lower working limit in relation to viscosity is somewhat more difficult. Crude temperature measurements which have been made have indicated that this point is somewhere between the temperatures in which the log viscosity of the glass was 6 and 7. Thus, for this study, it was decided to adopt as the upper limit of the working range the temperature where the log viscosity of the glass was equivalent to 3.0; and for the lower limit, the temperature where the log viscosity was equivalent to 6.0. This corresponds to the recommendations made and adopted at the joint meeting of the Deutsche Glastechnische Gesellschaft and the Society of Glass Technology.[1]

In flow-machine operation, actual temperature measurements at the feeder showed the upper limit of the working range to be 1980°F for the size of bottles referred to in the operation of flint and amber glasses. For the compositions in question, this corresponded to a log viscosity of 3.40.

Table I shows the actual chemical compositions and the temperatures necessary to get log viscosities from 2.0 to that corresponding to the respective fiber softening points (shown by Lillie[6] to be 7.65) of the four glasses studied. The viscosity values were obtained by high-temperature determinations, using the falling-sphere method described by Hunter,[7] at some four temperatures for each glass, from 2400°F down to the liquidus temperature of the glass in question. Determination of the fiber softening point was made by the method described by Littleton,[5] and the calculation of the equation for the viscosity curves was obtained by an empirical equation described by Fulcher.[8]

V. Test Results

Table I indicates that the temperature limits which were sought to compare the relative setting rates of the flint and emerald green glasses in Owens operation, *i.e.*, from the temperatures necessary to get log viscosities of 3.0 to 6.0, were

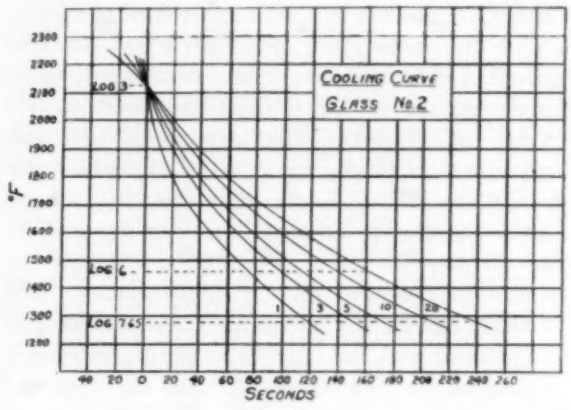

FIG. 3.

from 2178° to 1485°F and from 2124° to 1459°F, respectively. Cooling curves for these determinations at depths of 1, 3, 5, 10, and 20 millimeters are shown in Fig. 2 for glass No. 1, and in Fig. 3 for glass No. 2. It may be noticed that these curves have been extended to temperatures below those

[6] H. R. Lillie, "Viscosity of Glass between the Strain Point and Melting Temperature," *Jour. Amer. Ceram. Soc.*, **14** [7] 502–11 (1931).

[7] R. G. Hunter, "Application of Stokes' Law in the Determination of the Absolute Viscosity of Glass," *ibid.*, **17** [5] 121–27 (1934).

[8] G. S. Fulcher, "Analysis of Recent Measurements of the Viscosity of Glasses: II," *ibid.*, **8** [12] 789–94 (1925).

TABLE I

	No. 1 flint (Owens operation)	No. 2 emerald green (Owens operation)	No. 3 flint (flow operation)	No. 4 amber (flow operation)
SiO_2	73.5	71.5	71.8	70.4
R_2O_3	0.7	0.8	1.6	3.1
CaO	6.0	6.0	9.6	9.7
MgO	4.0	4.3	0.3	0.3
BaO	0.6	0.6	0.6	0.1
Na_2O	15.0	16.6	15.7	16.4
Log η =				
7.65 at °F	1294	1278	1310	1317
7.00 " "	1359	1341	1368	1375
6.00 " "	1485	1459	1477	1477
5.00 " "	1643	1614	1616	1625
4.00 " "	1859	1841	1814	1823
3.40 " "			1980	1980
3.00 " "	2178	2124	2107	2111
2.00 " "	2673	2590	2577	2575

corresponding to the fiber softening points of the glasses.

Table II shows the cooling time obtained at various depths for glasses Nos. 1 and 2, *viz.* (*a*) from temperatures where log viscosities are 3.0 to 6.0 and (*b*) from temperatures where the log viscosities are 3.0 to 7.65.

TABLE II

	(*a*)		(*b*)	
Depth (mm.)	Glass No. 1 (2178°–1485°F)	Glass No. 2 (2124°–1459°F)	Glass No. 1 (2178°–1294°F)	Glass No. 2 (2124°–1278°F)
1	81	74	128	121
3	103	98	159	154
5	117	113	179	174
10	143	139	215	210
20	164	160	240	240

As previously mentioned, it is the writers' opinion that the rate of change of viscosity of the surface of the glass is the controlling factor in the rate at which a glass article may be fabricated. Table II indicates that at 1 millimeter below the glass surface, the time required for the emerald green glass to cool from the temperature where its log viscosity is 3.0 to that where it is 6.0 is 74 seconds, and the corresponding time for the flint glass is 81 seconds. This appears to parallel actual operating experience, wherein it was found that faster operating speeds were obtainable on glass No. 2 than on glass No. 1. It is true that the actual speeds obtainable with glass No. 2 were approximately 15% greater than those with glass No. 1 and the results of the test show that at 1 millimeter depth glass No. 2 cools only approximately 9% faster than glass No. 1. It should be remembered, however, that in these tests approximately 17% of the total glass area only is actually exposed and that in at least two points in the cycle of bottle operation, approximately 90% of the glass area is exposed. Furthermore, under the test conditions, heat is removed from the glass principally by radiation and secondarily by convection and conduction, while in actual bottle operation it is probably removed primarily by conduction through the mold iron and secondarily by radiation and convection. At any rate, the results seem to indicate conclusively that the darker-colored or green glass, No. 2, radiates heat much more rapidly from its surface than does the flint glass, No. 1.

To show that the differences in temperature intervals at which the tests were conducted were not responsible for the differences in cooling times obtained near the surfaces of No. 1 and No. 2 glasses, cooling-rate measurements were made on

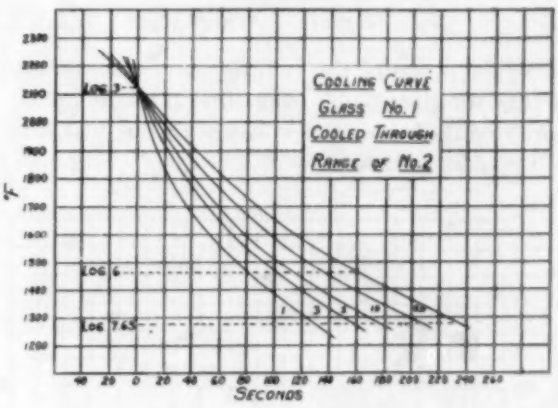

FIG. 4.

No. 1 glass throughout the interval used in the measurements reported in Table II on No. 2 glass (2124° to 1459°F and 2124° to 1278°F). These cooling curves at the various depths for glass No. 1 are shown in Fig. 4. The numerical values showing time in seconds necessary at various depths for glass No. 1 to cool throughout the range used in the measurement of the cooling properties of glass No. 2 are shown in Table III.

TABLE III

	(*a*)		(*b*)	
Depth (mm.)	Glass No. 1 (2124°–1459°F)	Glass No. 2 (2124°–1459°F)	Glass No. 1 (2124°–1278°F)	Glass No. 2 (2124°–1278°F)
1	81	74	131	121
3	102	98	157	154
5	116	113	175	174
10	140	139	210	210
20	161	160	240	240

Figure 5 (constructed from Figs. 3 and 4) shows the temperature gradients existing in glasses Nos. 1 and 2 at the end of 74 seconds, at which time glass No. 2 (1 mm. below the surface) has a viscosity of one million poises.

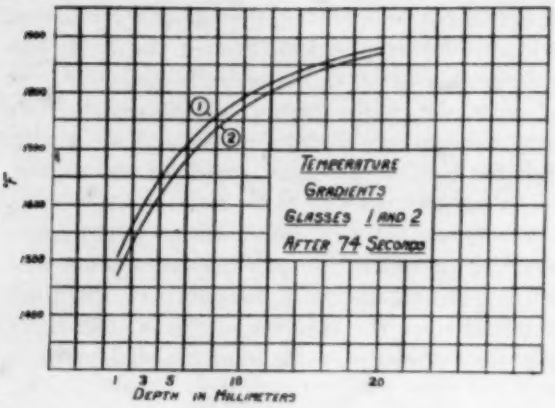

FIG. 5.

Figure 6 shows the cooling curves at various depths for glass No. 3 from 1980°F to a temperature slightly below that at which the log viscosity of the glass is 7.65.

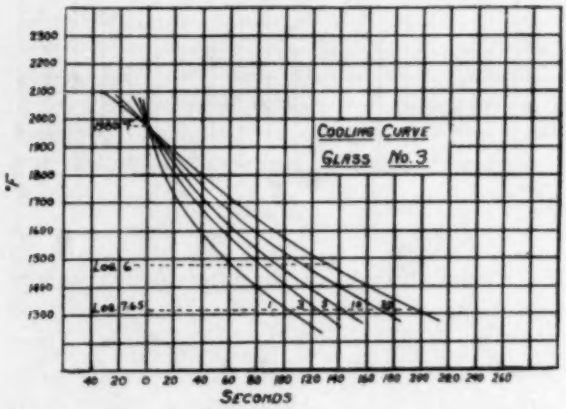

FIG. 6.

Figure 7 shows the corresponding cooling curves for glass No. 4. The time, in seconds, required for glasses No. 3 and No. 4 to cool from (*a*) 1980°F to the respective temperatures at which their log viscosities are 6.0, and (*b*) 1980°F to the temperatures corresponding to their respective fiber softening points, are shown in Table IV.

From Table IV, it is seen that amber glass No. 4, 1 millimeter below the surface, cools throughout the temperature interval from 1980° to 1477°F

TABLE IV

Time in seconds

Depth (mm.)	(*a*) Glass No. 3 (1980°–1477°F)	(*a*) Glass No. 4 (1980°–1477°F)	(*b*) Glass No. 3 (1980°–1310°F)	(*b*) Glass No. 4 (1980°–1317°F)
1	62	57	103	98
3	82	79	126	123
5	93	91	144	144
10	112	110	170	170
20	132	131	196	196

5 seconds faster than the flint glass No. 3 throughout the same temperature interval. It has been mentioned that over a period of one year, in the

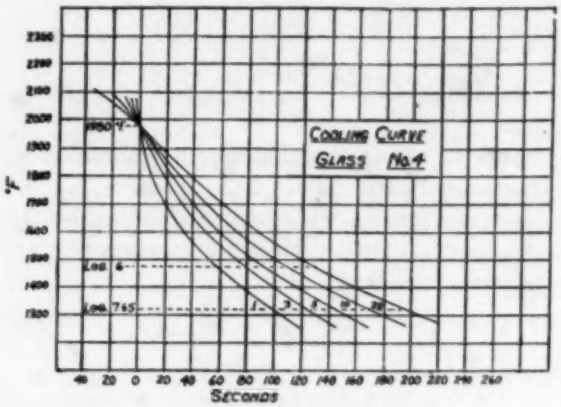

FIG. 7.

manufacture of relatively large ware with these two glasses, an average speed of 20.8 bottles per minute was obtained in amber glass operation and of 19.9 bottles per minute in flint glass operation. This corresponds to a greater speed of

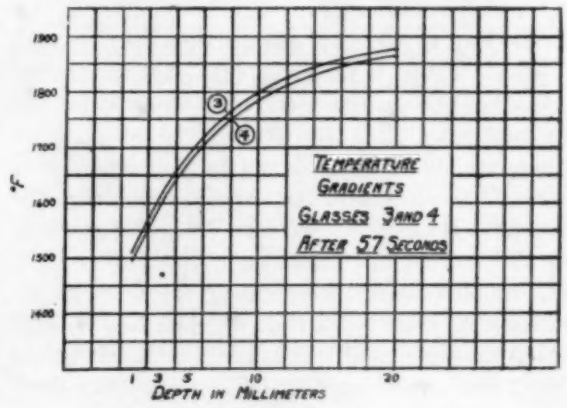

FIG. 8.

approximately 4½% in favor of the amber glass. The cooling rates, at 1 millimeter, show the amber glass to be cooling 8% faster than the flint glass.

Figure 8 shows the temperature gradients existing in glasses Nos. 3 and 4 after an elapsed time of 57 seconds when the cooling rates were measured from an initial temperature of 1980°F. Data for this figure were taken from the curves shown in Figs. 6 and 7.

VI. Conclusions

The results appear to explain, at least to some extent, the ability to manufacture similar sizes and shapes of bottles at faster speeds with dark-colored glasses than can be obtained with colorless or flint glasses. The results indicate that this should be true, even though the two types of glass have identical viscosity characteristics. The more rapid setting of the colored glasses is unquestionably due to a greater rate of loss of heat by radiation from their surfaces, causing the viscosity of such surfaces to increase at a greater rate than the surfaces of flint glass.

The test procedure, although perhaps somewhat crude and admittedly not exactly duplicating actual conditions in bottle operation, does appear to give results directional in estimating comparative speeds obtainable with dark-colored and colorless glasses not only of the same composition but of different compositions. This test may be used, in conjunction with viscosity measurements, to estimate closely the speeds obtainable with different compositions of glass, either colored or colorless.

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LINEAR THERMAL EXPANSION OF "BETA-ALUMINA" *

By J. B. Austin

Abstract

An attempt to determine the linear thermal expansion coefficient of a sample of "beta-alumina" containing 4.47% K_2O and 1.03% Na_2O was unsuccessful because the expansion was irregular and not reproducible. On successive heatings, the expansion approached more and more closely that of alpha-alumina (corundum). This observation, together with the fact that the fused-silica parts of the expansion apparatus were badly etched during the measurements, apparently by alkali given off by the sample, gives further support to the view that "beta-alumina" is not an allotropic form of pure alumina but is an alkali aluminate.

I. Introduction

About ten years ago, in the course of a series of measurements of the linear thermal expansion of crystals of refractory oxides, an attempt was made to determine the expansion coefficient of a sample of "beta-alumina." The attempt was unsuccessful because the results obtained were highly irregular and were not reproducible. It was observed, however, that on successive heatings the expansion became more regular and at the same time approached more closely the expansion of alpha-alumina (corundum), which suggested that the "beta-alumina" was being converted to the alpha form. This behavior was very puzzling, because "beta-alumina" at that time was still considered to be an allotropic modification of pure alumina, and as no satisfactory explanation was found, these data were not published with the results for other oxides.

Since that time the structure and stability of "beta-alumina" have been the subject of a number of investigations[1] with results which have led to a radical change in the accepted view of the nature of this material; thus, it is now generally, though not universally, held that "beta-alumina" is not an allotropic modification of pure Al_2O_3 but is an alkali aluminate. As our dilatometric data are entirely consistent with this new view, and indeed give additional, if indirect, support to it, and as they demonstrate the ease with which the potassium-type "beta-alumina" may be decomposed, it is felt that their publication is now justified.

* Presented at the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 31, 1938 (Refractories Division). Received April 16, 1938.

[1] For a summary of these investigations see R. R. Ridgway, A. A. Klein, and W. J. O'Leary, "Preparation and Properties of So-Called 'Beta-Alumina,'" *Trans. Electrochem. Soc.*, **70**, 71 (1936); *Ceram. Abs.*, **16** [7] 209 (1937).

II. Method of Measurement and Sample

The measurements were made with an interferometric dilatometer which has already been described.[2] The rate of heating was 3.5 ± 0.5 °C per minute.

NOTE: The sample was a mass of fused "beta-alumina" obtained through the courtesy of J. B. Glaze of the Norton Co. The chemical analysis, for which the writer is indebted to W. D. Brown, Carnegie-Illinois Steel Corp., showed the following composition: Al_2O_3 92.25, SiO_2 0.20, TiO_2 none, FeO 0.30, K_2O 4.47, Na_2O 1.03, and ignition loss 1.59%.

A large piece of this material was broken with a hammer, and a number of small but well-formed plates were selected from the chips with the aid of a binocular microscope. Three of these plates of substantially the same thickness were selected and, by lightly touching them on a grinding stone, were brought to the proper thickness to give good interference fringes. These specimens were then placed in the interferometer so that the broad surfaces lay parallel to the fused silica plates. The expansion was measured, therefore, in a direction perpendicular to the cleavage plane. Two sets of such specimens were tested.

III. Results

The results for two successive runs with the first set of specimens is shown in Fig. 1. During these runs the distance between fringes did not

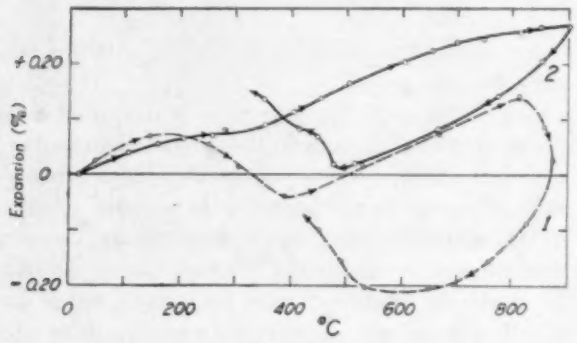

FIG. 1.

change appreciably nor was there any change in the direction in which the fringes moved, indicating that the unusual expansion observed was not due to erratic behavior on the part of one of the specimens but was characteristic of all three. The thickness of the specimens decreased from 0.250 mm. at the start to 0.235 mm. at the end of the second run. There was, however, no recognizable change in the optical properties as a result of the heating.

The results for the second set of specimens, on which four successive runs were made, are shown in Fig. 2. Only three runs are represented in the figure, however, because the points for the fourth

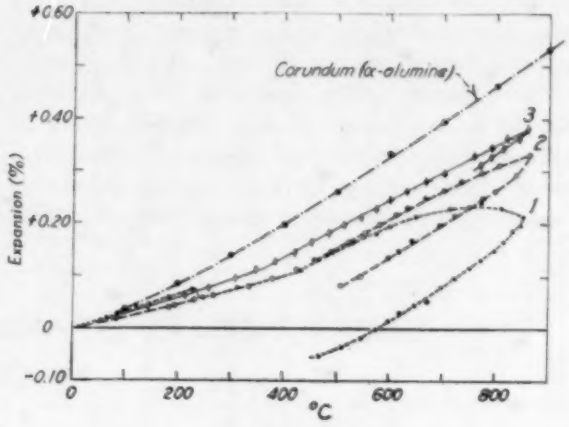

FIG. 2.

run lie so close to those for the third that to include both would lead to confusion. The expansion curve for a mass of fused corundum is also included for comparison.[2]

In both sets of measurements the fused silica plates were badly etched.

IV. Discussion and Conclusions

The form of the expansion curves shown in Fig. 1, with the curious dip at about 400°C, is unusual, although other examples of this kind are not unknown. Substantially, the same type of curve was obtained by the author in the first run on a zircon crystal,[2] and similar curves are given by Merritt[3] for mixtures of thoria and zirconia. In the measurements on zircon, there was a loss of the characteristic blue color on heating, and the anomalous behavior was not observed on a second run, both of which imply that the irregular expansion curve was associated with some change taking place on heating. No satisfactory explanation for curves of this type has been found, but it seems likely that they are obtained only when the material decomposes or when there is a

[2] J. B. Austin, "Thermal Expansion of Some Refractory Oxides," *Jour. Amer. Ceram. Soc.*, **14** [11] 795–810 (1931).

[3] G. E. Merritt, "Thermal Expansion of Some Fused Oxides Used as Refractories," *Trans. Amer. Electrochem. Soc.*, **50**, 165 (1926); *Ceram. Abs.*, **6** [1] 27 (1927).

reaction going on between two constituents in the sample. As far as the author is aware, such a curve has never been reported for a pure oxide, from which it seems logical to conclude that "beta-alumina" is not a pure oxide but is either a mixture or an easily decomposed aluminate.

Although the expansion of the second set of specimens does not show the dip at 400°C observed with the first set, there is a marked change in slope at approximately this temperature, which indicates that the same change was taking place, but to a smaller extent, or possibly less rapidly. The nature of the change at 400°C is not certain and deserves further detached study.

With each successive heating, the expansion of the second set of specimens came closer to the expansion of an aggregate of corundum crystals, which is shown by the uppermost curve in the diagram. This trend is evident from the curves in Fig. 2 but is even more clearly illustrated by the change in the instantaneous expansion coefficient at 600°C. For corundum, this coefficient is 6.5×10^{-6}, whereas for the first, second, third, and fourth runs on "beta-alumina" it is 4.3, 5.4, 5.7, and 5.8×10^{-6}, respectively. This progressive approach to the properties of alpha-alumina indicates that "beta-alumina" is not stable but is gradually converted to corundum even at the moderate temperatures to which it was exposed in these measurements. Further support for this conclusion is provided by the observation that during the course of the measurements the polished surfaces of the fused-silica interferometer plates became badly etched, a condition which is clearly the result of attack by alkali vapors given off by the specimens. There is, therefore, little reason to doubt that the "beta-alumina" was giving off alkali and changing to alpha-alumina.

The magnitude of the change between the curves for successive runs is surprisingly large and illustrates how easily the potassium "beta-alumina" may be decomposed. Ridgway, Klein, and O'Leary[1] call attention to the fact that the "beta-alumina" is much more easily converted to alpha-alumina if the alkali is K_2O than if it is Na_2O, and they report that in one test the K_2O content was reduced from 7.90 to 0.24% by heating to 1275°C for one hour. The curves in Fig. 1 show that an appreciable amount of conversion can be obtained at much lower temperatures, inasmuch as no measurements were carried above 900°C and the sample was not exposed to this maximum temperature for more than a few minutes.

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FAILURE OF COKE-OVEN WALLS BY REACTION WITH COAL ASH*

By W. C. Rueckel

Abstract

The failure of coke-oven walls by slagging is described and data are presented which trace the source of the damaging material to the coal. Mechanism of failure is explained with the help of phase-rule diagrams for the systems $FeO–SiO_2$ and Fe and O_2.

I. Introduction

Various types of failure of coke-oven walls have been discussed in which failure was produced by thermal or mechanical stresses. Failures from mechanical stresses have resulted from inadequate relief of expansion of brickwork and by the force of expanding coals. Reaction between the ash in coal and the oven lining at high temperatures has produced a type of oven failure unique in American coking practice. It is a failure of this type that is to be discussed in this paper.

The conditions mentioned arose at a plant in the western part of this country. The first battery of thirty-three ovens was completed and placed in operation in December, 1923, while the second battery of twenty-three ovens was put into operation in January, 1928.

The coal used at this plant is probably the lowest rank of coal being coked in by-product ovens in the United States. It is a high oxygen coal, containing from 36 to 40% of volatile matter. Because of its high oxygen content, the coal can not be stored for long periods of time without seriously impairing its coking ability. When the ovens were first put into operation, it was found that the coal must be rapidly coked in the ovens by maintaining high wall temperatures. It should be remembered that underfiring requirements are higher when coking a high oxygen coal than when coking low oxygen coal.

When the coal involved in this study is coked in ovens with low wall temperatures, the coke is found to be of poor quality for use in the blast furnace so that, to produce satisfactory coke at this plant, high wall temperatures prevail when the coke is pushed. The combination of these circumstances and the fact that oven gas is used for underfiring result in high flue and chamber temperatures.

Early in 1934, frequent "stickers"[1] were encountered in the operation of battery No. 1. An examination of the ovens indicated that brick in the lower half of the oven walls were being attacked (slagged) and worn away. Conditions rapidly became worse, and by the end of 1934 a few ovens were taken out of service. By September, 1935, the entire battery of thirty-three ovens had to be cooled and dismantled prior to rebuilding.

II. The Investigation

An inspection of the cold battery before dismantling showed that the disintegration of the oven walls varied in degree from oven to oven. In each oven, however, the attack appeared to be localized in a very definite area. Figure 1 shows a typical view of an oven wall in which the disintegrated area is indicated by the shaded portion. It can be seen that a small part of the bottom and all of the top half of the oven walls were not subject to slagging and that the flues adjacent to the oven doors were not attacked. Figure 2 shows a cross-section of an oven wall and indicates the extent to which some of the brick were affected.

The disintegration of the oven liners usually started at the third tier from the floor and extended through the sixth tier. The areas at the start were localized near the ends and at the center of the ovens; at this stage, mortar joints and edges of the brick were not slagged and projected beyond the center portion of the liners. After erosion proceeded to a depth greater than $1/4$ inch and extended over three or more flues, the joints were no longer prominent. Despite the depth of erosion, in some cases 2 to $2\,1/2$ inches, a layer of vesicular slag with a thickness of $1/4$ inch was found on the surface of the brick. The erosion in fact appeared to progress in steps removing successive layers of the brick. The slag surface seemed to be a ferrous silicate. The slag resembled pumice, and its porosity appeared to result either from the evolution of gas in a liquid or the solution of material in the interstices of the silica brick or both.

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 23, 1937 (Refractories Division).

[1] "Sticker" is a term used by the by-product coke industry to describe a charge of coke that can not be pushed from the ovens by mechanical means.

Readings of wall temperatures were taken in battery No. 2, which was operating while the first battery was being demolished.[2] The bottom half of the walls on the oven side was found to be

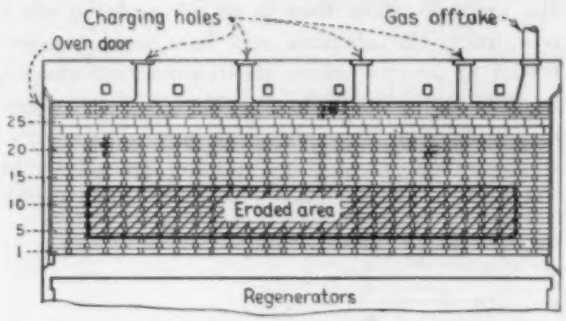

FIG. 1.—Lateral section through oven chamber.

at temperatures of 2250° to 2275°F a few minutes after pushing the charge of coke. This temperature is 150° higher than has been observed at any other plant.

Samples of coal and wall brick were selected for laboratory tests at the time the ovens were inspected. A portion of the coal sample was used for ash-fusion tests, and the remainder was used for float- and sink-tests.

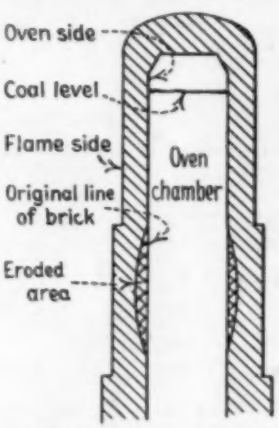

FIG. 2.—Cross-section through oven wall and coke chamber.

All test data for coal-ash fusion temperatures obtained from the coke plant records were about 2600°F. The standard procedure of the American Society for Testing Materials for the determination of the fusion point of coal ash stipulates that the fusion shall be carried out in a reducing atmosphere. Actually, the atmosphere within the fusion furnace is often oxidizing because it is easier for the operator to advance the temperature of the fusion furnace in an oxidizing atmosphere. The tests showed that the fusion temperature of the fines (−65-mesh) in the coal used at this plant was about 2300°F in a reducing atmosphere. The fact that the ash had slagged the surface of the silica brick suggested that ash would dissolve the silica brick and produce a eutectic between the ash and silica. A silica brick was therefore ground to pass a 150-mesh sieve and was added to the ash from the fine coal in amounts of 5, 10, and 20%; a fusion test was then made of these mixtures in a reducing atmosphere. The addition of 20% silica lowered the fusion of the coal ash from 2300° to 2200°F.

In order to ascertain whether the coal in question contained large quantities of soluble salts, a leaching test was made. The content of soluble material was found to be 0.08%. The total quantities of lime and alkalis introduced into the ovens as soluble material in the coal were considered to be insignificant.

The ash-fusion data were corroborated by the results of the float-and-sink tests. Separation of float-and-sink portions were made at specific gravities of 1.35, 1.45, and 1.60, using mixtures of carbon tetrachloride and benzol. The fusion point of float-and-sink portions of the coal and other data are presented in Table I.

TABLE I

FUSION POINTS OF SINK-AND-FLOAT PORTIONS OF COAL UNDER INVESTIGATION

	Fusion temp. (°F)	Ash		
		Color	Content (%)	Fe_2O_3 (%)
Specific gravity 1.60				
Sink	2088	Purple-red (1.9% of total coal)	50.7	38.74
Float	2804	White ash	35.4	5.22
Specific gravity 1.45				
Float	2804	White ash	16.8	
Specific gravity 1.35				
Float	2804	White ash	3.8	
Raw coal			7.2	

As can be seen from Table I, the fusible part of the coal ash is concentrated in the sink 1.60 portion, which has a fusion temperature of 2088°F. An examination of the coke produced in the ovens shows that it contains two types of ash; one is white and very refractory and the other is red and high in iron. The sulfur content of the sink 1.60 specific gravity portion of the coal was 13%. By calculations, it can be shown that 32% of the 39% iron in the ash of the sink 1.60 portion of the coal originally existed as pyrite or marcasite (FeS_2). Petrographic examination has proved that it is chiefly marcasite.

[2] This battery, built four years later than battery No. 1, also showed evidence of slagging and disintegration of oven liners. It afforded an excellent opportunity to study the slagging in its initial stages.

In several ovens, liners were found that had resisted the attack of iron while the brick immediately surrounding them were all affected. These brick had a peculiar greasy appearance similar to that of soapstone. One such sample was obtained for chemical and petrographic analyses. In addition, brick from the slagged areas and from the upper part of the oven wall were obtained for chemical and petrographic analyses. The chemical analyses of various brick are presented in Table II.

TABLE II

CHEMICAL ANALYSES OF BRICK FROM THE COKE PLANT

	Soapstone surface	Slagged brick			Cement layer	Probable original cement	Probable original brick
		slag	edge	center			
Silica	96.48	89.18	94.38	96.10	93.22	93.2	96.3
Alumina	1.44	3.96	2.37	0.89	3.05	4.8	0.89
Iron oxide	0.58	4.12	0.99	0.99	0.87	0.9	0.8
Lime	1.04	2.37	2.35	1.96	2.53	1.1	2.0
Magnesia	0.31						
Alkali	0.27						
	100.12	99.63	100.07	99.94	99.67	100.0	99.99

Alumina = $Al_2O_3 + TiO_2$.

The analysis of the soapstone surface does not suggest an explanation for the failure of the brick to be attacked by fusible constituents of the coal ash. The alumina content is higher and the lime content lower than when the brick was placed in service.

The analyses for the slagged brick are for a liner brick in which the center of the oven face was badly slagged; the edge of the brick in contact with the cement was white and free from attack by iron. The analysis of the center of the brick, back several inches from the face, can be considered a good average analysis of the brick as placed in service. It is evident that the slagged surface is high in iron and alumina, while the lime content has increased slightly over what it was when the brick was placed in service. The analyses for the edge of the brick and for the cement layer show that alumina had migrated from the cement into the edge of the brick until equilibrium was reached. The migration of alumina into the edge of the brick undoubtedly had a marked effect on its resistance to attack by fusible coal-ash constituents.

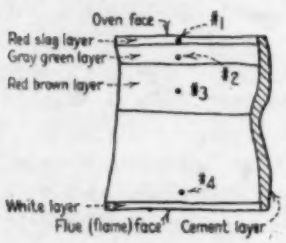

FIG. 3.—Section through liner showing location of samples for chemical analyses.

Harvey[3] has described migration of lime and alumina in silica brick from open-hearth roofs. His analyses show that in an uninsulated silica roof brick the alumina and lime were concentrated in a zone where the temperature ranged from 1100° to 1300°C. Analyses of four points in a coke-oven liner obtained from the battery, which indicate migration of lime, are shown in Table III. The oven face (No. 1) in contact with the coal was at a temperature of about 1200° to 1250°C; No. 4 (the flame side) was at a higher temperature. It can be noted that there has been a tendency for the alumina to increase in the cooler part of the brick, and the lime has been concentrated at the center of the brick (see Fig. 3 for location of samples).

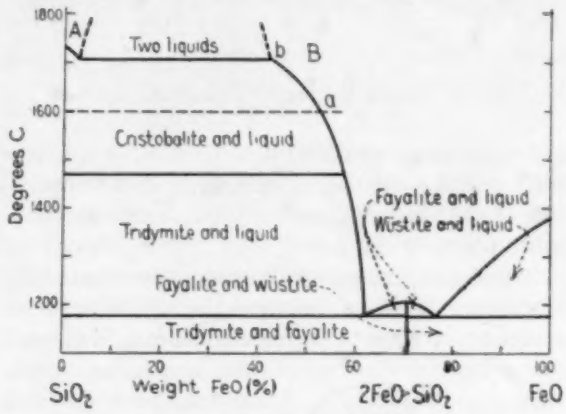

FIG. 4.—System FeO–SiO_2.

TABLE III

CHEMICAL ANALYSES OF AN OVEN LINER* IN SERVICE TEN YEARS

	(1)	(2)	(3)	(4)
Silica	93.6	92.5	93.1	96.6
Alumina	1.6	1.6	1.6	0.7
Iron oxide	3.5	3.3	2.1	0.6
Lime	1.3	2.5	3.2	2.0
Magnesia	0.2	0.2	0.1	0.1
Alkali	0.2	0.1	0.1	0.1
	100.4	100.2	100.2	100.1

(1) Oven face, coal side.
(2) ½ in. from oven face.
(3) 2 in. from oven face.
(4) Flue (flame) side.

* Liner 5 in. thick.

[3] F. A. Harvey, "Comparison of Used Silica Brick from Insulated and Uninsulated Basic Open-Hearth Roofs," *Jour. Amer. Ceram. Soc.*, **18** [3] 86–94 (1935).

Thin sections of the glazed surface and various portions of a slagged brick were prepared and examined with a petrographic microscope. Before discussing the results of an examination of the various thin sections, it seems advisable to discuss thermochemical equilibrium relations of FeO and SiO_2. Figure 4 is an equilibrium diagram for the system, wüstite–silica. In this system, a compound, fayalite, is found which has the composition of 72% FeO and 28% SiO_2. If mixtures of FeO and silica are heated to 2145°F, a liquid is formed from which fayalite will crystallize on cooling.

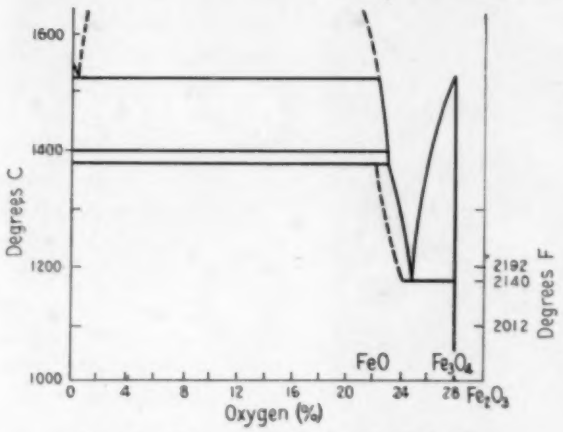

FIG. 5.—The system iron–oxygen (Fe–O).

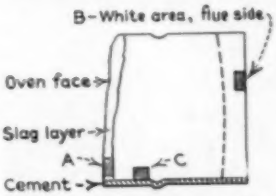

FIG. 6.—Location of thin sections.

The system, iron–oxygen, is shown in Fig. 5. At 2140°F, a eutectic is formed between iron and oxygen, and when the eutectic is subjected to the action of reducing gases, such as are found in coke ovens, oxygen will be liberated until the composition of FeO is reached. The release of oxygen to form a pumice on cooling in a sealed chamber of iron oxide-silica melts has been observed by Bowen and Schairer.[4]

The location of the various thin sections within the liner brick is shown in Fig. 6.

The appearance of the slagged surface under the microscope is shown in Fig. 7. The golden color indicates the presence of fayalite, and it can be seen bordering the pores and penetrating the interstices between the grains of tridymite. The presence of fayalite indicates that the slagged surface was heated to a temperature in excess of 2150°F. A few red streaks of hematite will be noted on the edge of the fayalite. The pores in the thin section are usually well rounded, indicating solution of silica. Some of the pores also appear to have been enlarged by entrapped gases. It is apparent that this surface can easily be abraded.

The thin sections also show a marked decrease in the amount of fayalite present in the brick beneath the slagged layer, even though chemical analyses (Table III) indicate that the iron content of the center of the brick has increased. It should be remembered that the slagged portion is usually about $^1/_4$ inch thick. Figure 5 indicates that a eutectic of iron and oxygen is formed at 2140°F in a reducing atmosphere. Because the iron and silica in the brick beneath the slagged surface are heated above 2140°F, the decreased fayalite content can be explained only by the inability of the reducing atmosphere to penetrate deeply into the brick.

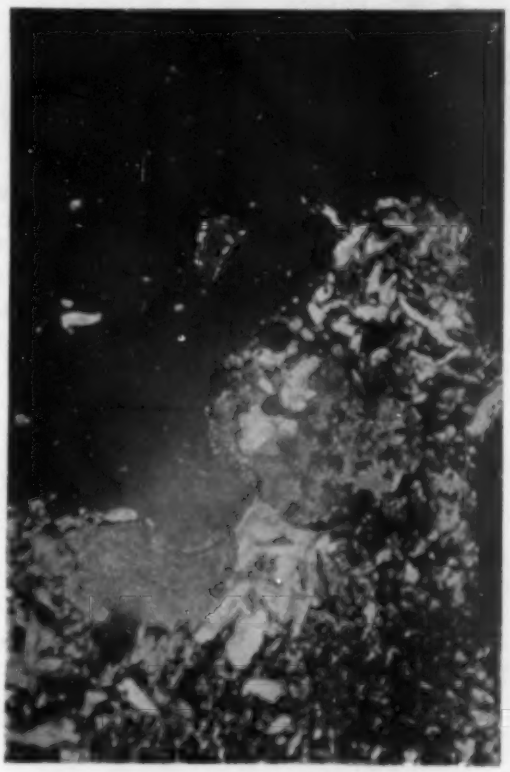

FIG. 7.—Slagged surface; crossed Nicols, 110×.

[4] N. L. Bowen and J. F. Schairer, "The System FeO–SiO_2," *Amer. Jour. Sci.*, [5] **24**, 177–213 (1932); *Ceram. Abs.*, **12** [2] 83 (1933).

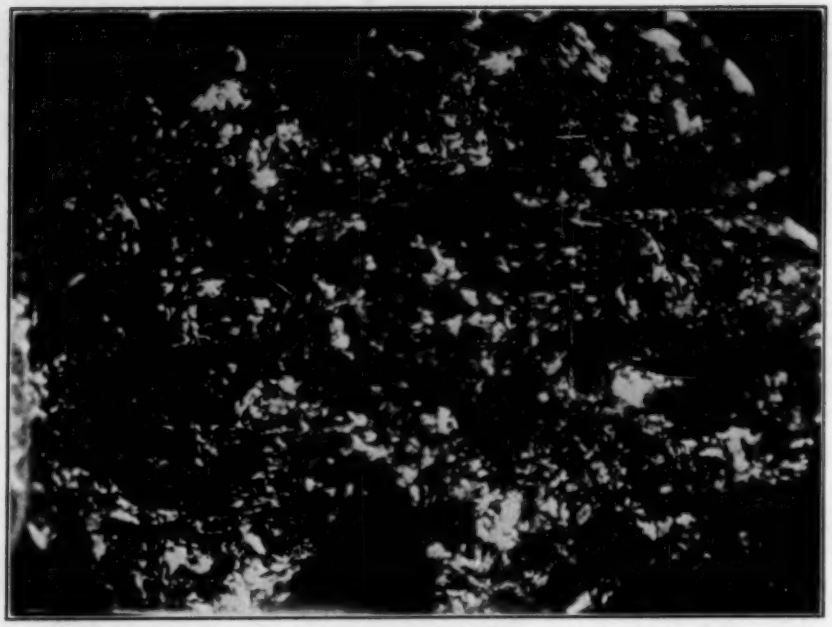

FIG. 8.—Flue edge of liner brick; crossed Nicols, magnification 110×. Fine ground mass of cristobalite; dark areas are also cristobalite crystals which are extinct under crossed Nicols.

FIG. 9.—Tridymite area $^1/_2$ inch from flue edge; crossed Nicols, magnification 110×. Tridymite crystals characterized by tabular wedge shape and pronounced twinning.

Silica brick as placed in service consist mainly of cristobalite and tridymite with small amounts of quartz, the relative amounts of the phases depending upon the firing treatment the brick received. After having been in service for a number of years, coke-oven liners usually convert completely to tridymite on the flue side. The tridymite content usually decreases toward the oven side of the brick at which point the mineralogical constitution approximates that of the brick as placed in service. These conditions exist when the flue temperatures range from 2300° to 2600°F.

If temperatures in excess of 2680°F are maintained in the flues, the brick will convert to a stable modification of cristobalite on the flue (flame) side. The center of the brick in such cases, however, will consist largely of tridymite.

The section of the flue side of the slagged brick is shown in Figs. 8 and 9. Figure 8 shows the marked development of cristobalite on the very edge of the flue (flame) side of the brick. Figure 9 shows that tridymite appears in the brick about $^1/_2$ inch from the flue edge. The indication is that flue temperatures in excess of 2680°F were maintained in the ovens for some time before they were cooled.

Figure 10 shows a portion of the oven side of the slagged brick (*C*) in contact with the cement. The section shows that this portion of the brick consists largely of cristobalite with small amounts of fayalite. An alumino-silicate glass, visible only at high magnifications, has evidently inhibited the penetration of iron and the formation of fayalite.

Figure 11 shows a thin section of the glazed brick surface. At low magnifications, the section shows a fine-grained mass of cristobalite crystals containing a number of small bleb-shaped inclusions of glass. Immediately below

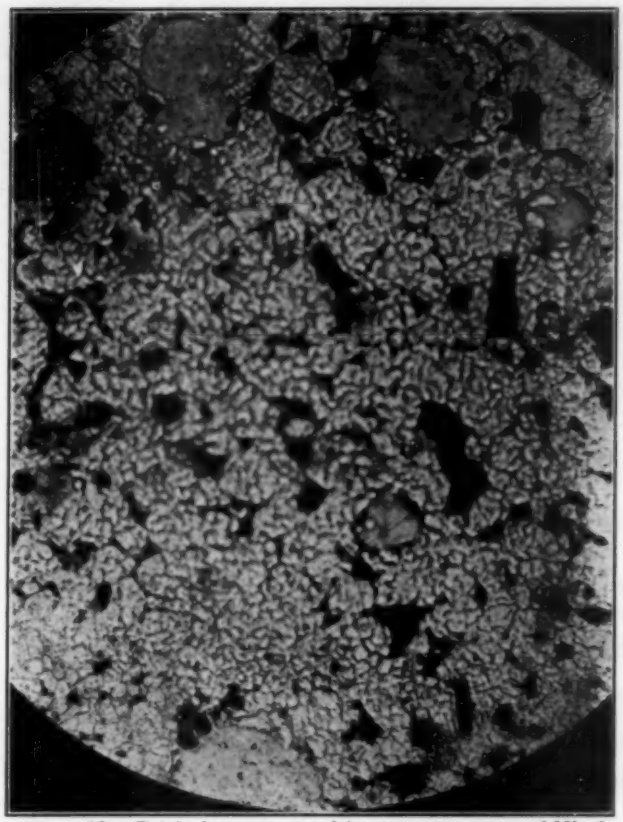

FIG. 10.—Brick in contact with cements; crossed Nicols, magnification 110×; gray area fine cristobalite crystals; glass visible only at higher magnifications.

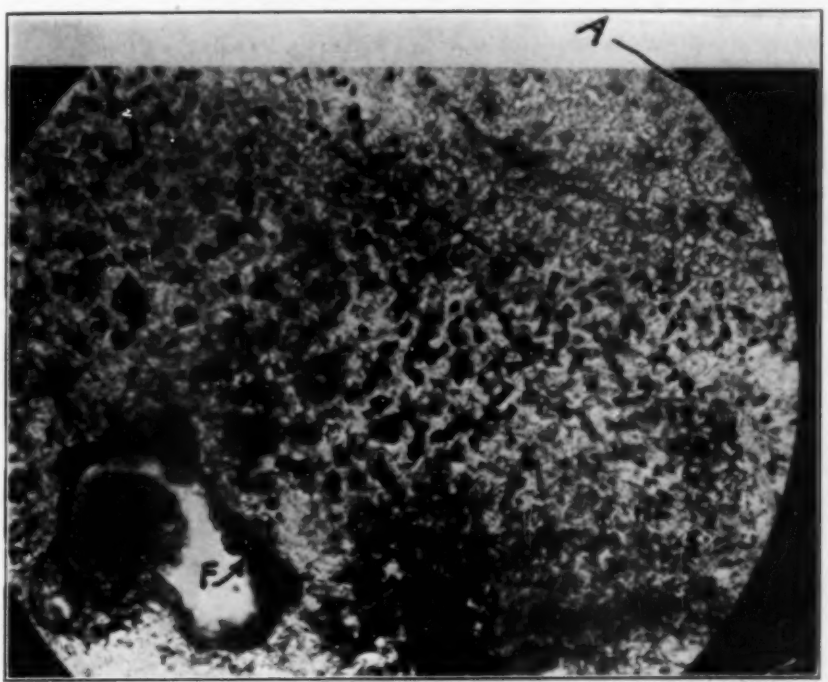

FIG. 11.—Glazed surface; parallel Nicols, magnification 110×. Depth of glazed surface from *A* to *B*; photograph shows all of the glassy layer and part of brick beneath it; attack of brick below glaze by fayalite (*F*) can be noted.

the glazed surface, which is only 0.02 to 0.04 inch thick, fayalite and tridymite can be observed.

III. Summary

A satisfactory explanation for the failure of certain brick with glazed surface to be attacked by fusible ash constituents is rather difficult to make. The development of glass, as in the case of brick in contact with cement, has undoubtedly retarded its failure. It must be remembered that in most of the glazed brick disintegration has started at a number of places resembling craters and that disintegration of the brick is spreading below the glazed surface.

The manner in which iron gets from the coal to the oven wall has been difficult to determine. Initially it was felt that the attack of the oven brickwork was caused by volatile substances formed during the coking process. Tests were made to determine whether iron carbonyl was formed when CO gas was passed through the coal. The tests showed that iron carbonyl was not formed. Later it was felt that because the iron in the coal was concentrated in the fines it could be carried to the walls in a stream of gas. Calculations show that about 200 days of operation would account for all of the iron present in the walls, if the iron in a $^1/_8$-inch layer of coal adjacent to the wall were abstracted by the brick.

The question arises, will high wall temperatures produce a similar type of attack in ovens regardless of the nature of the coal? Based on the findings of this investigation, the answer is that it will, if the coal contains iron that can get to the wall. The efficacy of washing the coal used at this plant depends largely upon the importance of the nature and occurrence of the iron as it affects oven deterioration. Some of

the questions relating to this problem are still unanswered and will require the substantiation of simulative tests in small ovens. Suffice it to say that oven deterioration of the type encountered at this plant or high inside wall temperatures as used have not been observed at any other coke plant in this country. If iron exists in the coal charged into coke ovens, it is indicated that the use of wall temperatures above 2150°F will ultimately result in a type of failure discussed in this paper.

IV. Conclusions

(1) Disintegration is caused by reaction of silica brick and iron in coal ash owing to the use of high chamber-wall temperatures.

(2) Disintegration is localized at the bottom half of the oven wall owing to the heavy combustion required to coke coal rapidly.

(3) Although iron penetrates half way through the brick, formation of pumice is limited to a layer on the oven side owing to the reducing action of oven gases.

(4) The slagged layer is removed by abrasion when coke is pushed from the ovens.

(5) A large portion of the iron in the coal can be removed by washing the coal, although it is questionable whether washing will do more than prolong the life of the ovens.

Acknowledgments

The author wishes to acknowledge his indebtedness to F. A. Harvey and E. P. Rexford, Harbison-Walker Refractories Company, for their assistance in this work.

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SOME CONSIDERATIONS IN THE PRODUCTION OF FUSED MULLITE FOR REFRACTORIES*

By Hobart M. Kraner

Abstract

The principles of the process of fusing ceramic materials for abrasives and refractories are now rather generally known. The benefits to be derived from the additions of fused materials to a refractory are likely to be (1) an increase of chemical resistance owing to the greater density and lower permeability, (2) an increase of load-bearing value of the product, and (3) a control of the kind and number of crystalline materials present in the grain as well as the proportion of glass contained. The term "flux" is not necessarily correctly used in connection with such fused materials, because it often applies only to a constituent which changes the proportions of the crystalline phases and does not affect the refractoriness or glass content.

I. Introduction

Clay refractories are resistant to spalling, but they fail to resist to a great extent the thermochemical attack to which they are often exposed. They deform plastically at high temperatures, and their load-bearing ability is therefore poor. Thermochemical resistance can be improved somewhat by the introduction of other materials which are more resistant in themselves and which do not dissolve as readily as the clay. Firing to a sufficiently high temperature reduces the porosity and improves the chemical resistance of the refractory.

Refractories which have been fired to high density are subject to the inherent chemical characteristics of that material, and these characteristics can be read from well-known diagrams. In the case of clay refractories, the alumina–silica system of Bowen and Greig is pertinent (see Fig. 1). Most clay refractories lie on the siliceous side of point *C*. When a temperature of 1545°C is reached in such a refractory, a liquid phase develops in some proportion, depending on the proximity of the composition to that of the eutectic. The addition of materials more aluminous than the clay composition decreases the amount of eutectic *B* in the mixture, thereby decreasing the tendency toward plasticity under load. The addition of kyanite, sillimanite, diaspore, or bauxite increases the refractoriness but requires higher temperatures to reduce the porosity sufficiently to give the refractory stability under load and added resistance to chemical action.

If such a refractory is porous, it permits the penetration of attacking fluxes much more readily

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 24, 1937 (Refractories Division). Received January 31, 1938.

than if the refractory had been fired to vitrification. A refractory containing 70% alumina poorly fired is radically different from a refractory of the same composition which has been fired to vitrification. The crystalline structure of these

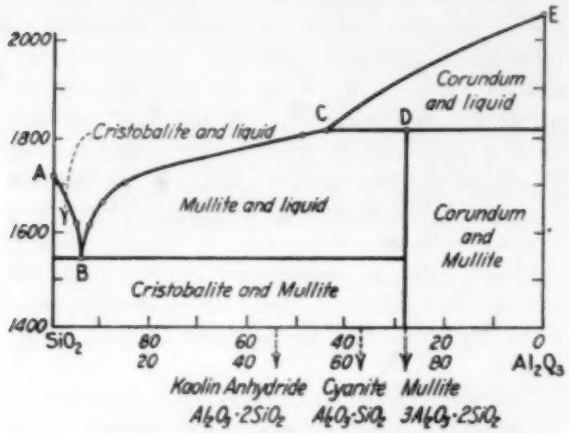

FIG. 1.—Alumina–silica system.

	Al_2O_3	SiO_2	Temp. °C
A		100.0	1710
B	5.5	94.5	1545
C	55.0	45.0	1810
D	71.8	28.2	1810
E	100.0		2050
K.A.	45.95	54.05	
Cyanite	62.85	37.15	

two refractories would be radically different, inasmuch as the porous refractory would contain tiny crystals, each of which would be thoroughly lubricated by a glassy phase, whereas in the vitreous products, the crystals of mullite would be large and in contact with each other, thereby being more capable of withstanding load.

II. Fusing of Aluminous Material

In 1894, Moyet developed a process of fusing aluminous materials for use as an abrasive by melting the material electrically. In 1896, he obtained a German patent on this process, which is still in use. In 1919, Malinovszky recognized the importance of having coarse-grained mullite in a refractory, and he developed a process of fusing aluminous materials in a cupola. An excess of coke reduced to some extent the silica which was present, leaving the material higher in alumina. This produced a dense, coarsely crystalline grog which was satisfactory for refractory purposes. Shortly after the development of the Malinovszky process, a number of workers, including those at the Bureau of Mines in Seattle, Washington, and at the Vitrefrax Company at Los Angeles, surveyed the possibilities of various alumina-silica mixtures which might be suitable for refractory purposes. In 1922 and 1923, fused products were on the market, which were used in refractories and porcelain. Several manufacturers of abrasives produced mullite by this process. Two reasons, however, for fused mullite not having extensive use in rebonded products are (1) variation in the characteristics in this product and (2) cost. One of the reasons for variation is the variable content of impurities in the raw materials which must be used and the effect of these impurities upon the crystalline ratios and upon the crystal-glass ratio. These were originally not very well understood, and in view of the lack of fundamental data, they are not now entirely explainable. Variations of those constituents, especially the alkalis, also affect the process seriously.

The method by which these materials are produced is simple and practically the same as that by which aluminous abrasives are made. The molten batch has a sufficiently high electrical resistivity to permit the use of common voltages

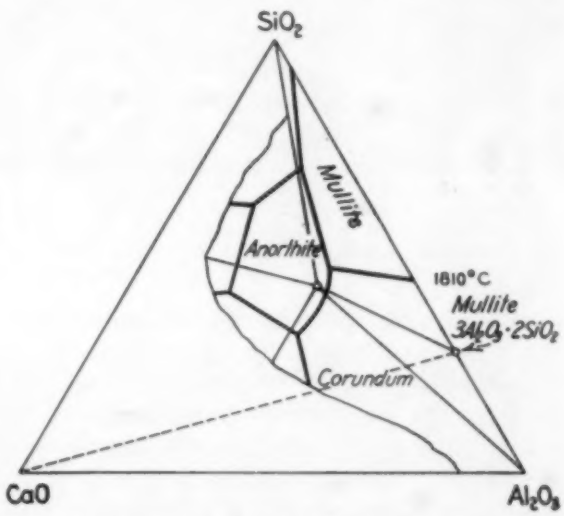

FIG. 2.—Ternary system CaO–Al_2O_3–SiO_2 (Rankin and Wright).

so that it is not necessary to use unusual designs of transformers or other equipment. When the batch is cold, however, the resistivity is so high that an arc must be drawn over the surface of the batch to melt a small portion, which then becomes conductive to carry the current from the immersed electrodes.

Ingots produced in such furnaces are generally coarsely crystalline unless the batch is relatively high in silica. Batches containing 40 to 50% SiO_2 produce finer grained mullite than those of lower silica contents.

III. Production of Noncrystalline Fused Mullite

When it is desired to have a fused mullite which is not thoroughly crystalline and is therefore unstable, the fused material is poured slowly into water or through a stream of water. If the melt

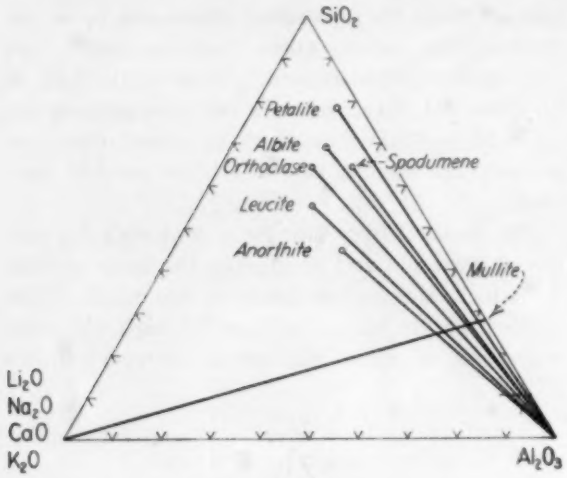

FIG. 3.

	SiO_2	Al_2O_3	LiO_2	CaO	K_2O	Na_2O
Albite	68.7	19.5				11.8
Anorthite	43.2	36.7		20.1		
Orthoclase	64.7	18.4			16.9	
Leucite	55.0	23.5			21.5	
Petalite	78.4	16.7	4.9			
Spodumene	64.5	27.4	8.4			

from which such an incompletely crystallized product is made contains a very high percentage of alumina, it is not likely that even such a quenching procedure will prevent crystallization of mullite, as the liquid is very fluid, and the tendency of mullite to crystallize is very great.

The fused material can also be poured through a blast of air which chills the pellets of liquid material before they strike floor level. Although they are still hot upon striking floor level, they do not adhere to one another and the grinding operation is thus minimized. Viscous, siliceous melts produce a stringy mass and can not be poured.

The tendency of fused mullite to crystallize is strong. The petrography of these products is therefore much more simple than that of fired clay refractories. Effects of solid solution of alumina, titania, and iron oxide in fused mullite are readily determined in the indices and other optical properties of the crystal.

Crystallization of aluminous melts, approximating the mullite composition, otherwise adheres fairly closely to fundamental rules. Even with pure mullite, crystallization from the melt produces corundum as the primary phase, total resorption taking place at *C* (Fig. 1). The high percentage of mullite in a quickly cooled melt of this composition leads one to believe that the liquid goes through the temperatures at which corundum should crystallize so rapidly that it does not have an opportunity to do so, and the temperature falls to a point where mullite automatically crystallizes without first forming corundum.

Melts richer in alumina than mullite would be expected to contain an excess of corundum. Melts richer in silica than mullite would be expected to contain an excess of glass over the mullite ratio.

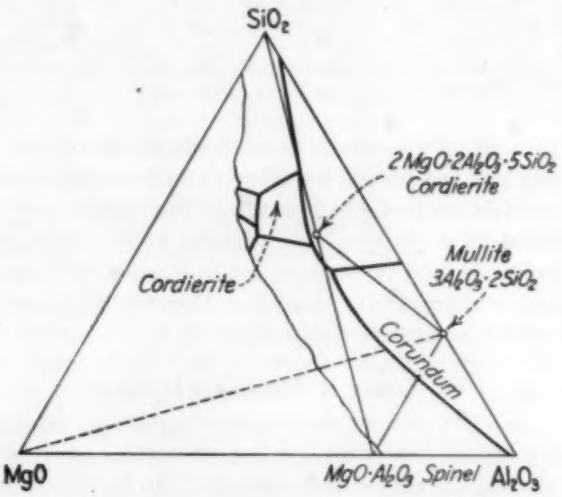

FIG. 4.—Ternary system MgO–Al_2O_3–SiO_2 (Rankin and Merwin and Bowen and Greig).

Owing to the tendency of mullite to dissolve alumina in solid solution, mullite which crystallizes from a melt higher in alumina than typical mullite compositions would be apt to contain alumina in solid solution. Melts, slightly richer in silica than mullite, frequently contain corundum on cooling. This latter may be due to the presence of a small percentage of impurities or to the physical difficulties encountered during the crystallizing process which prevented the entire resorption

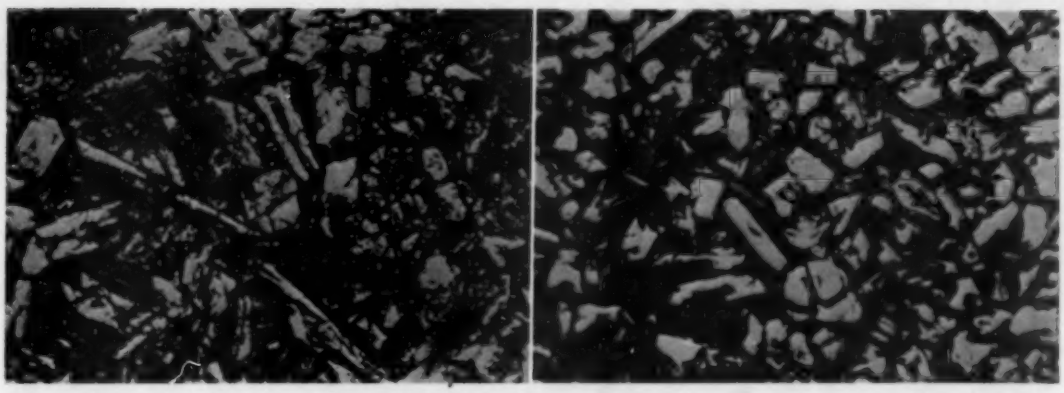

FIG. 5.—(*Left*) 65×. FIG. 6.—(*Right*) 65×.
Fused aluminum silicate-composition containing 14 and 16% SiO_2, respectively. Almost all of the crystalline portion seems to be corundum; the mullite is interstitial and fine-grained.

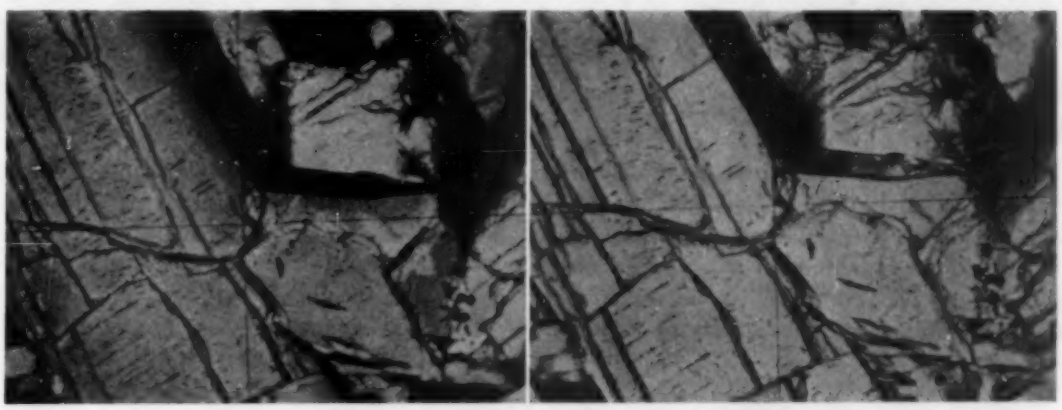

FIG. 7.—(*Left*) 65×, crossed Nicols. FIG. 8.—(*Right*) 65×.
Fused mullite composition containing 30% SiO_2, 69% Al_2O_3, and 0.20% alkalis; cooled in a large ingot; no corundum present. The coarse crystallization is due almost entirely to the character of the melt. Coarsest mullite crystallization is derived from melts slightly higher in SiO_2 than mullite, while the fine-grained types are derived from more siliceous melts. See Figs. 9, 10, 11, and 12.

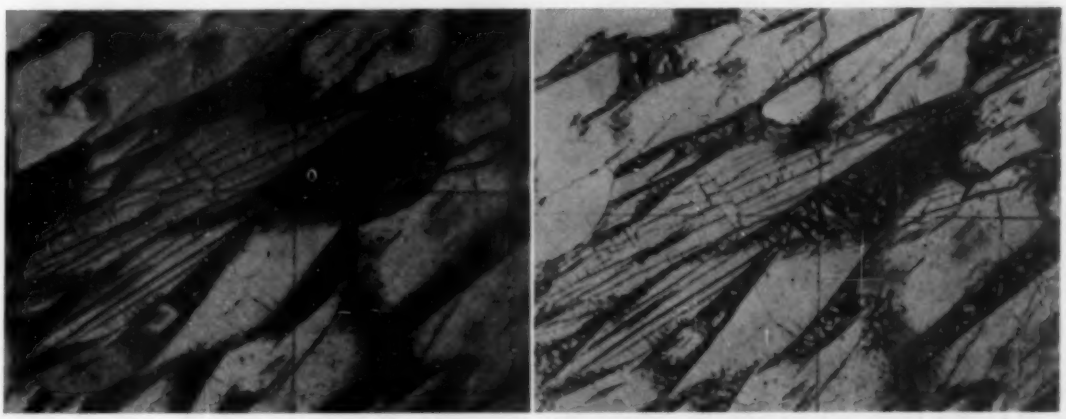

FIG. 9.—(*Left*) 65×, crossed Nicols. FIG. 10.—(*Right*) 65×.
Fused mullite composition obtained from a composition containing 33% SiO_2; note interstitial titania obtained from a bauxite batch.

of corundum. It would not be expected that such a composition would be sufficiently viscous to prevent resorption of corundum except through viscosity built up by the presence of a large amount of crystalline material, *i.e.*, solids, which inhibit the attainment of equilibrium.

cluded. Such mullite aggregates require a clay of relatively low refractoriness to bond them because the occluded glass is not available for this purpose. Coarsely crystalline mullite makes the glass readily available for bonding, and a more refractory clay may be used. Close control

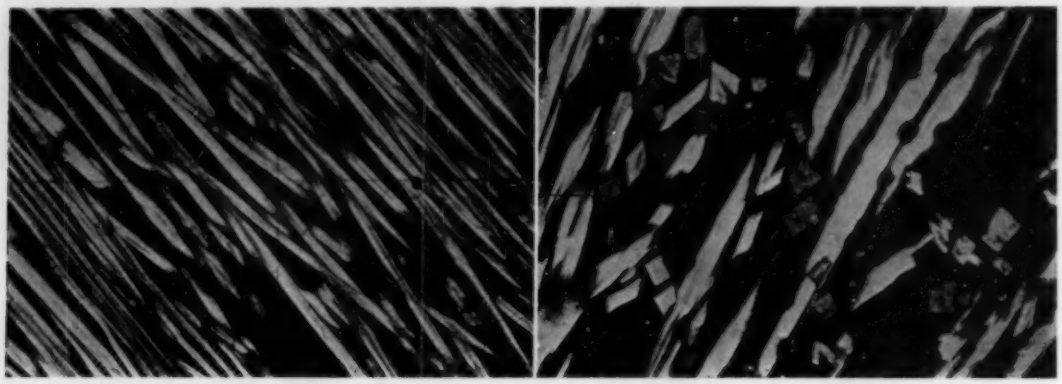

FIG. 11.—(*Left*) 65×, crossed Nicols; mullite from batch containing 54% SiO_2.
FIG. 12.—(*Right*) 65×, crossed Nicols; mullite from batch containing 45% SiO_2.

IV. Effect of Mullite Properties on Refractories

The properties of mullite seriously affect the characteristics of the product in which the mullite is used as the granular or "grog" constituent. In porcelain in which homogeneity is needed, the mullite should not contain corundum. For refractories, it is not desirable to use mullite which has been made with an excess of silica because this silica is present as a glass. A high percentage of silica in such a mixture promotes the crystallization of an extremely fine needlelike variety of mullite in which a large amount of glass is occluded. Such mullite aggregates require a clay of relatively low refractoriness to bond them because the occluded glass is not available for this purpose. Coarsely crystalline mullite makes the glass readily available for bonding, and a more refractory clay may be used. Close control of the alumina-silica ratio of fused mullite is therefore necessary to control the properties of the bonded product.

V. Raw Materials for Mullite Production

Kyanite, andalusite, bauxite, diaspore, and alunite residues and pure alumina concentrates with sand have been used as sources of raw materials for the production of mullite. Most of these, except the purest, contain relatively large amounts of titania, iron oxide, and other impurities. Iron oxide is easily reduced in

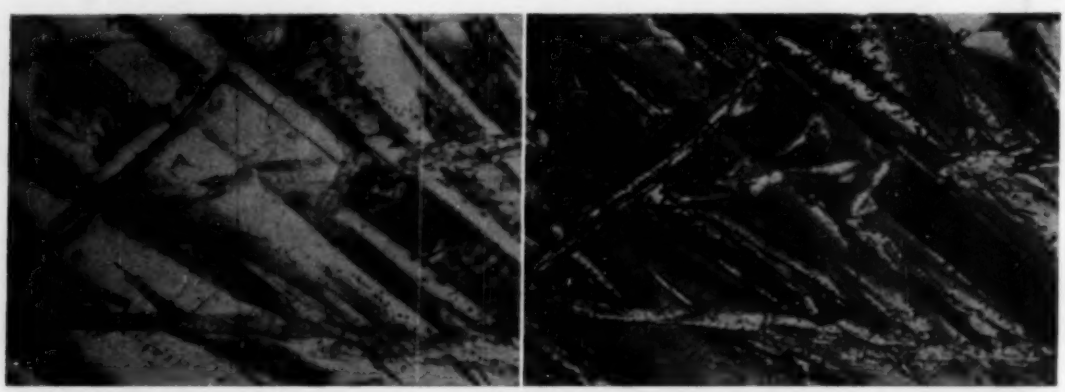

FIG. 13.—(*Left*) 65×. FIG. 14.—(*Right*) 65×, crossed Nicols.
Mullite and corundum in a melt containing 68% SiO_2, 1.27% alkalis, and 2.4 TiO_2. Note presence of residual corundum and glass induced by the action of alkali. Titania may be seen as black dendrites largely segregated in the glass.

melting and the final product has only a small amount present. Titania is not easily reduced and generally appears in the form of black dendrites. It is not likely that the titania and the iron oxide seriously influence the crystalline characteristics of the mass, but the alkalis, lime, and magnesia lower the temperature at which mullite and corundum are in equilibrium with each other. In other words, these impurities put the composition into ternary or more complex systems which extend the range of crystallization of corundum as a primary phase.

FIG. 15.—Coarse mullite crystals from a batch containing 4.7% MgO, showing that MgO, is not so good a "retarding agent" as the alkalis. This specimen is almost all mullite; the interstitial material probably is cordierite and spinel too fine-grained to identify; 4.7% alkali would have been sufficient to cause the entire removal of mullite in favor of corundum and glass. This suggests that if mullite is the desirable phase, it will not be as harmful in aluminum-silicate production as alkalis would be, insofar as the producer is concerned.

Mullite will be eliminated when approximately $11^1/_2\%$ of lime has been added to the mixture (see Fig. 2). It will be seen, therefore, how readily effective these so-called fluxes are in the alteration of the proportion of mullite, corundum, and glass. Anorthite does not crystallize as readily as does mullite or corundum, and its composition, therefore, would probably occur in a crystallized ingot as a glass, or the glass might even contain some additional alumina which could not crystallize as corundum or mullite owing to the viscosity of the melt after the temperature had fallen and after the crystallization of corundum had considerably increased the silica content of the glass.

The product of such a process of crystallization of a composition lying on the corundum–anorthite binary would be only corundum and anorthite. Abrasive manufacturers tell us that soda is so effective that only $4^1/_2\%$ of it is required to eliminate mullite entirely from such compositions. Thus it appears that the system involved here is mullite, albite, and corundum, and the albite–corundum binary system is considered for the effects of soda additions in such compositions.

The field of stability of mullite has been narrowed (see Fig. 3), principally by the location of the mineral, albite, in this system. Lithia is another alkali which has been tried to a limited extent and has been found to be effective. It is probable that corundum would form a binary system with one of the lithia-alumina-silica minerals high in silica, and if this happens to be the one that contains eight molecules of silica and whose composition is, therefore, $Li_2O \cdot Al_2O_3 \cdot 8SiO_2$, only 2% of lithium oxide is required to eliminate mul-

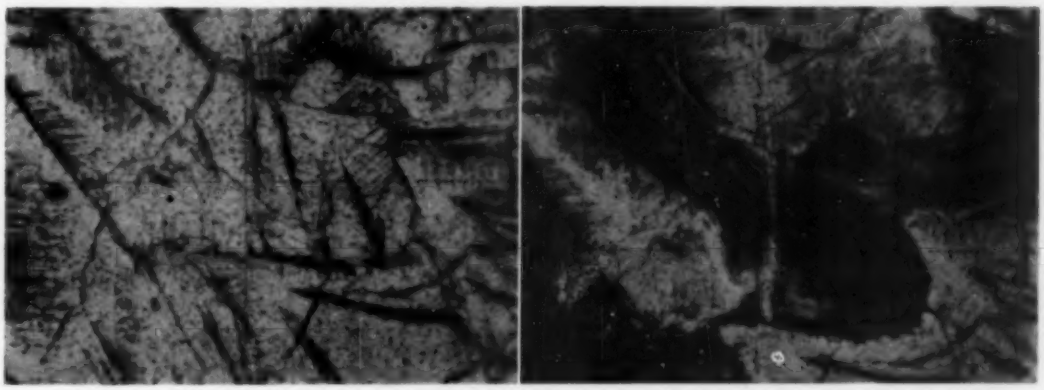

FIG. 16.—(*Left*) 65×. FIG. 17.—(*Right*) 65×, crossed Nicols.
A coarse granular type of mullite crystallization resulting from a relatively pure melt; only a trace of corundum and practically no glass are present.

lite from compositions approximating pure mullite (see Fig. 3).

In the system, magnesia–alumina and silica, mullite exists in melts containing as much as 26 or 27% magnesia where the alumina content is high. If magnesia were added to a composition approximately that of mullite, 22% would be required to eliminate mullite from the final product. The mineral relations are mullite, spinel, and cordierite as well as mullite, spinel, and corundum in adjacent systems (see Fig. 4).

Considerable unpublished work has been done on these systems by manufacturers of abrasives and of other fused aluminous products; they generally recognize the extreme sensitiveness to variations in these constituents within the systems, as explained in the preceding paragraphs. It is apparent from these comments why slight differences in alkali contents radically change the characteristics of the final product. The final percentage of alkalis is often affected by volatilization, and this must be considered in compounding the batch. The size of the batch is also a factor.

It seems opportune that the use of the term, "flux," in this connection should be discussed here. The contours within the systems of which there are fundamental data indicate that these so-called fluxes somewhat lower the fusion temperature of the compositions which are being studied. It has been shown here that the resulting mineral relations and their proportions are important. The abrasive manufacturer uses the term, "retarder," as it applies here, and this term seems to be more nearly correct in this sense.

It is the hope of the writer that these considerations will, in some measure, explain to those who use (or who expect to use) fused mullite in rebonded products what to expect as to the characteristics of the grain he receives. The study will also indicate to him the possible reasons for the characteristics of the various types of grain which are available to him and the reasons for their differences.

Acknowledgment

The author wishes to express his appreciation to the Vitrefrax Company, the Carborundum Company, the Exolon Company, and the Norton Company for their assistance in the preparation of fused mullite samples used in this paper.

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THE FRACTIONATION OF A CLAY INTO CLOSELY MONODISPERSED SYSTEMS*

By F. H. Norton and S. Speil

Abstract

The advantages of studying a clay by dividing it into a series of nearly monodispersed systems are brought out. A method for carrying this out is described, using a Florida kaolin as an example. The size distribution in each fraction is measured by settling methods, and good agreement is indicated between these sizes and the microscopically measured sizes.

I. Introduction

The division of a clay into a number of size fractions is particularly helpful when making a complete study of the clay. While in the past most of the work carried out on clays has concerned itself with the clay as a whole, there are many properties which can not be exactly evaluated unless nearly monodispersed fractions are being used.

Some of the results achieved by fractionating the clay are as follows: (1) the relation between the grain size of the clay and the physical properties can be closely evaluated; (2) the optimum grain size for a particular purpose can be readily chosen; (3) theoretical calculations for water-film thickness can be checked on actual values computed with the monodispersed systems; (4) the clay minerals and accessory minerals can be determined readily by studying the individual size fractions; (5) a study of the size fractions is particularly helpful in planning methods of washing or purifying the raw clay; and (6) microscopic measurement of particle size can best be carried out on fractions nearly uniform in size.

II. Methods Discussed

The methods available for dividing a clay into size fractions are numerous. In the relatively coarse sizes above one micron, settling of the dilute and deflocculated slips gives a simple means of producing definite sizes. These methods have been used commercially for washing clays and need not be discussed in detail. Another method applicable in the same size range is elutriation, whereby the clay particles are separated by a slowly rising stream of water. Perhaps one of the most efficient elutriators for small quantities of clay is the short-column machine developed by the Bureau of Mines.[1] For the separation of clay particles smaller than one micron, some type of centrifugal machine is needed. For laboratory work, the continuous Sharples supercentrifuge is satisfactory. The method of using this machine for fractionation has been fully described by Hauser and Reed,[2] and by Bray, Grim, and Kerr.[3]

III. The Sharples Supercentrifuge Method

After a considerable amount of experimental work had been carried out with these methods, it was found satisfactory to separate out the clay above one micron in size by repeated settlings and then to treat the finer sizes in the Sharples supercentrifuge. The settling was carried out in large galvanized iron cans for the required length of time; the suspended matter was siphoned off, more water added, and the coarse material reblunged. This process was repeated the required number of times to remove the fines. The curve in Fig. 1 shows the computed settling rate based on Stokes' law for various sizes. For example, if the clay fractions were to be split at 5 microns and the settling distance was 100 centimeters, the required time would be 12.6 hours.

The fine material was then passed, in the form of a dilute slip, through the Sharples supercentrifuge. The principle of this machine consists in allowing particles below a certain size to pass through the bowl and over the weir at the upper end. The particles remaining on the lining of the bowl, which is a sheet of thin celluloid, will be coarse and fine particles, and it is necessary to

* Presented at the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 29, 1938 (General Session on Constitution of Clay). Received January 24, 1938.

[1] S. R. B. Cooke, "Short-Column Hydraulic Elutriator for Subsieve Sizes," *U. S. Bur. Mines Rept. of Invest.*, No. 3333, pp. 39–51 (February, 1937).

[2] E. A. Hauser and C. E. Reed, "Development of a New Method for Measuring Particle-Size Distribution in Colloidal Systems," *Jour. Phys. Chem.*, **40**, 1169 (1936).

[3] R. H. Bray, R. E. Grim, and P. F. Kerr, "Application of Clay Mineral Technique to Illinois Clay and Shale," *Bull. Geol. Soc. Amer.*, **46**, 1909 (1935); *Ceram. Abs.*, **15** [5] 163 (1936).

reblunge this material and pass it through the centrifuge several times to remove the fines. The operation therefore is much the same as in the case of settling under gravity for the coarse

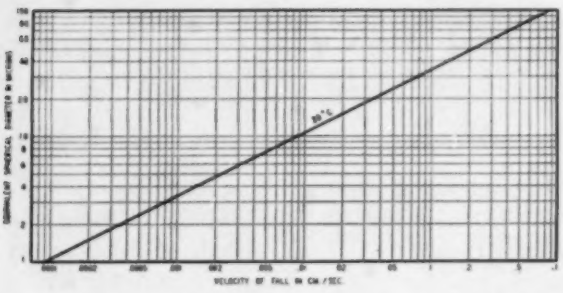

FIG. 1.—Settling rates from Stokes' law (for specific gravity of 2.60).

sizes. It has been found in practice that seven or eight trips through the centrifuge give a satisfactory fraction, but if a very sharp classification is desired this process may be repeated for several additional times.

A modification of this method consists in running the slip through the centrifuge as described, but instead of taking all the material off the liner at once, the liner is divided in height into two or more sections, each one of which is kept separate and separately run through the centrifuge in succeeding trips. This modification was not used in this problem.

It should be noted that if a fraction is needed whose size corresponds to the most frequently occurring particle size in the original clay, a considerable amount of carefully sized material may be readily produced. On the other hand, if a fraction is needed which is a little above this maximum in the original clay, then difficulty is found, and a greater number of trips are required to secure a good fraction.

IV. Mathematical Study of Particle Sizes

A mathematical study of the particle sizes settled out in this centrifuge has been worked out by Hauser and Reed[3] by an ingenious mathematical calculation. In Fig. 2, the curves of rate of feed and revolutions per minute for various size cut-offs from their equations are shown. For example, if a fine material below 0.2 micron is needed, the slip would be passed through the apparatus at a rate of 50 centimeters per minute and with a centrifugal speed of 8500 revolutions per minute. For careful sizing, it is advisable not to run the rate of feed much above 100 cubic centimeters per minute. This, of course, makes a rather slow separation of the clay particles if any considerable quantity of the material is desired. In order to produce a kilogram of a carefully sized fraction, it takes several months of steady work. If only a few grams of a fraction are required for X-ray, petrographic studies, or chemical analysis, the fractionation is not unduly laborious.

As an example of this method, 300 grams of Edgar plastic kaolin are blunged thoroughly in 3750 cubic centimeters of water and a deflocculent of 3 grams of No. 23 Daxad is added. This slip is carried through the schedule shown in the flow sheet of Fig. 3, which enables it to be split up into seven fractions. The concentration of the suspension is kept at about 2% throughout the centrifugal operation.

V. Purity of Fractions

To determine the purity of these fractions, particle-size measurements were made on each by the Casagrande hydrometer method, previously described,[4] and cumulative particle-size curves are plotted in Fig. 4. In addition to the experimentally determined curve, a straight line is drawn between the limits set in preparing that particular fraction. This line has no theoretical significance, but it is convenient for comparison. The depar-

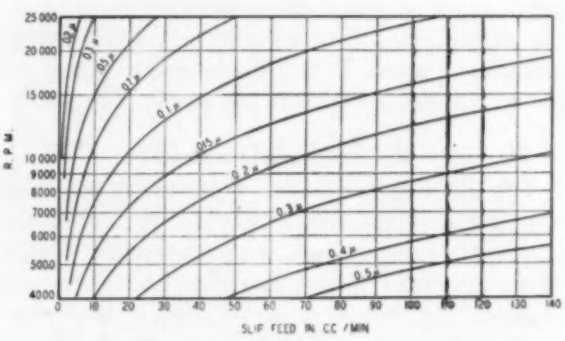

FIG. 2.—Size cut-off with the Sharples' supercentrifuge (for specific gravity of 2.60 and 20°C).

ture of the experimental curve from this straight line is only slight in the coarsest and finest fraction. In the coarse fraction, the limits of size were definitely set by screens, which accounts for the

[4] F. H. Norton and S. Speil, "Measurement of Particle Sizes in Clay," *Jour. Amer. Ceram. Soc.*, **21** [3] 89–97 (1938).

excellent agreement. In the finest fraction, the agreement is good because the fraction was so close to the lower size range of particles in this particular clay that the lower limit was automatically set by the material itself. In the case of the other fractions, the measured size in all cases is smaller than planned because of the difficulty in washing out the fine particles from the coarse ones. In the case of the fractions 44 to 10 microns, 5 to 10 microns, and 5 to 1 micron, the difference is comparatively small; but in the case of the 1 to 0.5 micron and 0.5 to 0.25 micron fractions, the fines have not been re-

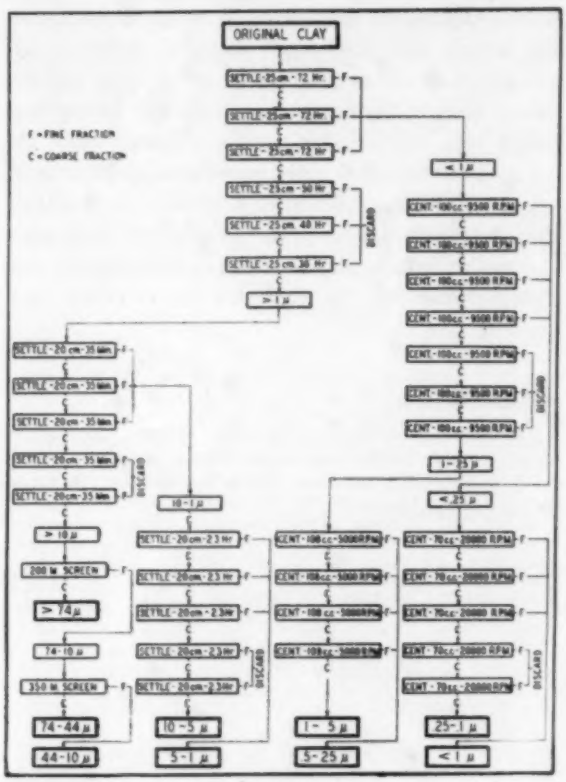

FIG. 3.—Flow sheet.

moved by any means completely, because the work here is on the coarser side of the distribution peak of the natural clay.[5] It will always be found extremely difficult to get closely sized fractions on the coarse side of any natural peak because of the great difficulty in removing the numerous fine particles. It will also be observed that two of the fractions cover a double range as compared with the others, namely 44 to 10 and 5 to 1 microns. These can, of course, be split again into two separate fractions, but in the particular clay studied this was not found necessary.

The characteristics of these fractions are summarized in Table I, where the purity of the fraction is arbitrarily expressed as the ratio between the diameter range and the mean diameter, basing the diameter range in the case of the measured curves at 10 and 90% weight in order to eliminate the slight error in the particle-size measurements close to the 0 and 100% point caused by the length of the hydrometer bulb. It will be noticed that the measured purity of the fraction compares well with what would be expected, except for the fractions 1 to 0.5 micron and 0.5 to 0.25 micron for the reasons previously explained.

TABLE I

CHARACTERISTICS OF THE FRACTIONS

Diameter range computed from settling times or centrifuge rates	Measured diameter range by Casagrande method (between 10 and 90% wt.)	Mean diameter by Casagrande method (at 50% wt.)	Measured diameter range divided by measured av. diameter	Diameter of greatest frequency by direct microscopic measurements
74–44 μ	68–38 μ	58 μ	0.6	60 μ
44–10	28–8.0	14	1.1	15
10–5	7.5–3.6	5.4	0.7	6
5–1	3.7–1.0	1.8	1.5	2
1–0.5	1.1–0.2	0.42	1.3	
0.5–0.25	0.55–0.12	0.23	1.3	
0.25–0.10	0.38–0.10	0.17	1.2	

A careful measurement of particle sizes in the coarser fractions was made with the microscope by immersing the clay particles in an oil having a refractive index of 1.53, which was low enough to make the outline of the grain distinct and yet minimize the diffraction error. In the measurement, each clay grain was focused on separately in order to get as close as possible to the true diameter. The sizes given in the last column of Table I represent the most frequent sizes appearing in the fraction, and it should be noted that the determination of this size in a closely fractioned clay is much easier than in a natural clay where a large range of sizes is present; in fact, any size work should be carried out on carefully prepared fractions. It is interesting to observe the close agreement between the mean diameter determined by the Casagrande method and the mean diameter determined by the microscope. In other words, there is no appreciable correction, at least in the coarser sizes, which needs to be applied to the Casagrande values to give

[5] F. H. Norton and S. Speil, *loc. cit.*, see Figs. 4 and 5.

the true diameters. This is probably true, because the large proportion of the clay particles in the larger size ranges consists of cylindrical particles with a diameter slightly less than the length, comprising broken-off sections of kaolinite worms. Probably the smaller size fractions consist of more platelike material which is broken off by cleavage from these worms. It is unfortunate that at the present time there is no direct method

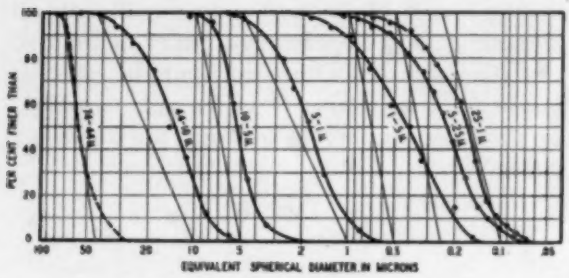

FIG. 4.—Particle-size distribution of fraction.

to measure the diameter of these smaller fractions, but from indirect evidence it is probable that even here no large correction factor need be applied to the Casagrande values to give the true diameter.

There is an interesting phenomenon which is always observed in the settling of these fractions or in the complete clay, *e.g.*, a definite stratification of the sediment into three and sometimes four distinct bands with a very sharp line of demarcation. As yet, there is no explanation for this phenomenon as there certainly is no differentiation owing to particles of different specific gravity, nor is there any sudden change in particle diameter. A still more striking example of this hydro-sedimentation was observed some years ago when a sample of banded opal was ground very fine in a ball mill and allowed to settle from a dilute suspension in water. After a few weeks, the material was consolidated in the bottom of the vessel, but it had arranged itself in definite colored bands having the same appearance as the bands in the original opal.

VI. Proper Dispersion of Clays

The question of proper dispersion of clays for any work concerning classification requires careful study. It is desirable to obtain complete deflocculation to get accurate settling data, but too severe agitation may actually decrease the natural particle size of the clay by cleaving the rather fragile kaolinite worms in the larger size range into thin plates which may go into the finer fractions. The only successful method is to standardize on a definite procedure of treating the clay, as it may not be possible to determine any point where deflocculation is complete and disintegration of the particles has not yet commenced.

Acknowledgment

This paper describes a portion of a fundamental research on clays being carried out in the Ceramics Laboratory of the Massachusetts Institute of Technology for the Edgar Brothers Company.

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CERAMIC ABSTRACTS

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October, 1938
17—10

Abrasives

Applying high finish to axe blades. Warren Axe and Tool Co. *Steel*, **100**, 60, 62 (Feb. 1, 1937).—The high polish on woodsmen's axes is applied to reduce friction and increase penetration. Edging (or scribing) is accomplished by grinding with a rubber-bonded wheel of 36 grit manufactured alumina, 30 in. in diameter with a 4-in. face, operating at a surface speed of 8000 ft./min. The grits used are for roughing 36, finishing 60, dry fining 80, and oil fining 120. After heat treating, the axes are polished with stitched canvas wheels, 18 in. in diameter with a 4-in. face, operating at a surface speed of 8000 ft./min. H.E.S.

Change in glass surfaces during grinding and polishing. H. Brandt. *Schleif- & Poliertech.*, **15** [3] 46–49 (1938); see *Ceram. Abs.*, **17** [9] 302 (1938). F.E.V.

Grinding machines at the Leipzig spring fair. P. Wiessner. *Schleif- & Poliertech.*, **15** [3] 49–54 (1938).—13 illustrations. See *Ceram. Abs.*, **17** [3] 91 (1938). F.E.V.

Heat measurements in the preparation of metallic polished sections. G. Kritzler. *Giesserei*, **25** [1] 2–6 (1938).—When preparing sections for microscopic examination, care should be taken that the temperature of the surface does not rise too high during the polishing or grinding process as structural changes causing incorrect results might take place. K. describes a method by which the temperature can be measured by thermocouples distributed in the specimen to be prepared. If any temperature rise must be avoided, polishing must be done under water, and the pressure with which the specimen is pressed against the grinding wheel must be very low. M.H.

Important machines and tools for utmost finishing. K. Donath. *Schleif- & Poliertech.*, **15** [2] 19–25 (1938).—D. describes the two principal processes (drilling and grinding) and discusses tools and machines. These methods should be used when possible. 19 illustrations. F.E.V.

Machines for manufacturing grinding disks. E. Brinkmann. *Schleif- & Poliertech.*, **15** [2] 30–32 (1938).—The machines finishing the plane and the cylindrical surfaces are described. 4 illustrations. F.E.V.

Polishing and buffing in the electroplating industry. Oskar Krämer. *Metallwaren-Ind. & Galvano-Tech.*, **35** [July 15] 292–94; [Aug. 1] 314–16; [Aug. 15] 336–39; [Sept. 1] 357–59; [Sept. 15] 381–83; [Oct. 1] 402–403; [Nov. 15] 466–68 (1937); *Metals & Alloys*, **9** [7] MA433 (1938).—K. gives an exhaustive review of various polishing media and buffing methods and their application in preparing metal surfaces for plating and finishing of plated articles.

Precision operations used in making large roller bearings. F. B. Jacobs. *Steel*, **100**, 34–36 (Jan. 11, 1937).—Illustrated. H.E.S.

Surface defects and their importance in the practical behavior of metallic materials. V. S. Prever. *Ind. Meccan.*, **19** [5] 316–21 (1937).—P. discusses the close relations between surface quality and mechanical properties, in particular decarburization in surface layers by heat treatment and welding in members subject to bending or torsional stresses. The apparatus for measuring roughness and unevenness is described. The reduction in dynamic strength shown by a C steel under different surface treatments is given. M.H.

BOOKLET

Abrasives and abrasive products. Anon. *Nat. Bur. Standards Letter Circ.*, No. 527. 8 pp. Free. The manufacture of the artificial abrasives silicon carbide, corundum, and boron carbide and their use in various products are discussed. R.A.H.

PATENTS

Abrading roll. W. J. Maddox (Even-Cut Abrasive Band & Equipment Corp.). U. S. 20,817, Aug. 2, 1938 (Dec. 4, 1933); reissue of original U. S. 1,883,747, Oct. 18, 1932.

Abrasive article. R. P. Courtney (Bakelite Corp.). U. S. 2,124,055, July 19, 1938 (May 18, 1934).

Abrasive articles. Compagnie des Meules Norton (Soc. Anon.). Fr. 822,055, Dec. 20, 1937; *Chem. Abs.*, **32**, 3570 (1938).—In the manufacture of grinding wheels, etc., by molding and hardening a mixture of a granular abrasive material and a phenolic resin, improved results are

obtained by including in the mixture a small proportion of a dehydrating agent, *e.g.*, CaO, partly dehydrated $Al(OH)_3$, soluble $CaSO_4$, or silica gel. An example is given.

Abrasive-coated disks. W. J. TENNANT (Carborundum Co.). Brit. 488,303, July 20, 1938 (Feb. 25, 1937).

Abrasive disk. H. O. SUNDHAUSS (J. L. Eisendrath, Jr.). U. S. 2,125,742, Aug. 2, 1938 (Sept. 26, 1936).

Abrasive products and methods of manufacturing. CARBORUNDUM CO. Brit. 488,033, July 13, 1938 (Dec. 30, 1935).

Abrasive wheel. EDWARD VAN DER PYL (Norton Co.). U. S. 2,124,279, July 19, 1938 (Oct. 9, 1936). An abrasive article comprises abrasive grain and a bond mainly comprising iron and ferric chloride.

Adjusting devices for machine tools, particularly for grinding machines. K. JUNG (trading as K. Jung Maschinenfabrik). Brit. 489,193, Aug. 4, 1938 (March 27, 1936).

Apparatus for grading emery. K. C. BURROUGHS (Bausch & Lomb Optical Co.). U. S. 2,124,343, July 19, 1938 (Jan. 3, 1935).

Apparatus for grinding. C. H. SCHMALZ. U. S. 2,127,071, Aug. 16, 1938. Original application Nov. 16, 1928; renewed Jan. 14, 1933, now U. S. 1,973,511, Sept. 11, 1934; divided and this application Aug. 9, 1934.

Apparatus for grinding, polishing, or cleaning wire. P. H. HAKANSSON. Brit. 487,733, July 6, 1938 (Aug. 13, 1937).

Articles of ceramic bonded abrasive material and methods of making. NORTON GRINDING WHEEL CO., LTD. Brit. 488,641, July 27, 1938 (Nov. 7, 1935).

Buffing or polishing wheel. A. W. L'HOMMEDIEU (C. F. L'Hommedieu & Sons Co.). U. S. 2,124,114, July 19, 1938 (Oct. 16, 1936).

Cylinder grinder. R. C. BENNER AND R. L. MELTON (Carborundum Co.). U. S. 2,125,061, July 26, 1938 (Nov. 16, 1934).

Device for feeding abrasives to glass-grinding tables. PILKINGTON BROS., LTD. Ger. 655,788, Jan. 6, 1938 (Jan. 18, 1936); XII/67*a*. 15. The abrasive material is fed from an opening in the well of the device to the middle of a rotating grinding tool which grinds the glass strip from the underside. The well is connected to the grinding tool by means of a lead and is provided with an overflow so that the level of the abrasive well can not be raised above the level of the working surface of the grinder. D.A.B.

Device for grinding and polishing level surfaces, e.g., mirror glass. LUMIÈRE CLARTÉ SOC. ANON. Ger. 655,502, Dec. 30, 1937 (Jan. 23, 1932); XII/67*a*. 15. By means of several machining tools which rotate around their own axes as well as around a common axle to which they are fixed, level surfaces such as glass mirrors can be ground and polished. The grinding tool and the polishing tool, which are fixed over the work piece, are driven independently of each other and independently of the rotating motion of the entire system. D.A.B.

Device for grinding and sharpening razor blades. FERDINAND SOUCZEK (Siemens, Inc.). U. S. 20,805, July 19, 1938 (March 16, 1938); reissue of original U. S. 2,004,838, June 11, 1935.

Grinder. F. J. GAMMACHE. U. S. 2,126,879, Aug. 16, 1938 (May 5, 1936).

Grinding and lapping machine. H. W. DUNBAR (Norton Co.). U. S. 2,127,210, Aug. 16, 1938 (July 31, 1937).

Grinding machine. A. O. SCHAEFER (Atlantic Service Co., Inc.). U. S. 2,124,593, July 26, 1938 (Jan. 8, 1937). F. O. WELLS (C. E. Adams). U. S. 2,124,093, July 19, 1938 (July 5, 1935).

Grinding wheel. T. J. MCINTYRE (Macklin Co.). U. S. 2,126,403, Aug. 9, 1938 (May 22, 1936). An abrasive device comprises a ring having an annular seat, a plurality of grinding wheel segments being disposed in the form of a cylinder in the seat.

Honing device. HERBERT CORRALL AND B. A. STEVENS (Singer Mfg. Co.). U. S. 2,127,289, Aug. 16, 1938 (Feb. 5, 1936).

Knife-sharpening device. GUILLAUME BARSCH (Industrie A. G. Allegro). U. S. 2,124,646, July 26, 1938 (Feb. 8, 1936).

Machines for grinding or sharpening knives. A. J. STANLEY. Brit. 487,973, July 13, 1938 (March 8, 1937); addition to 475,216, Dec. 1, 1937.

Making abrasive articles. R. C. BENNER AND R. L. MELTON (Carborundum Co.). U. S. 2,124,666, July 26, 1938 (Oct. 19, 1936). In the manufacture of abrasive-coated products, the steps comprise preparing an aqueous suspension of a normally solid phenolic resin in water, coating the backing with abrasive grains and with the suspension, removing the water from the suspension, and treating the article with a solvent for the resin to make the resin adhesive.

Making abrasive tools with conducting properties. R. N. HEALD (Heald Machine Co.). U. S. 2,125,782, Aug. 2, 1938 (Nov. 16, 1936). A method of treating an abrasive element of a porous nature consists in subjecting the element to the action of pressure developed centrifugally within a mass of colloidal graphite completely surrounding the abrasive element.

Making a boron carbide composition. J. A. BOYER (Carborundum Co.). U. S. 2,124,538, July 26, 1938 (March 23, 1935). The method of making a metallic composition containing boron carbide crystals comprises forming a mixture of solid boron carbide and a metal of the group of metals having atomic numbers from 26 to 29 inclusive, the quantity of metal in the mixture being in the proportions to form a substantially continuous matrix upon fusion and solidification of the mixture, heating the mixture until it becomes fluid, and thereafter cooling the resultant mass to cause crystallization of the dissolved boron carbide.

Manufacture of ceramic-bonded abrasive materials. NORTON GRINDING WHEEL CO., LTD. Brit. 488,004, July 13, 1938 (Nov. 21, 1936); addition to 482,351, April 6, 1938.

Polishing composition. HUBERT DEGUIDE. U. S. 2,126,096, Aug. 9, 1938 (Feb. 28, 1935). A polish comprises a mixture of barium stearate 55% by weight, paraffin of melting point 50° to 52°C 28% by weight, and hard wax 17% by weight, colloidally dispersed in spirits of turpentine in a stable gelled condition.

Portable grinding machine. A. W. MALL. U. S. 2,126,336, Aug. 9, 1938 (Dec. 3, 1936).

Portable polishing machines, etc. H. SCOTT-PAINE. Brit. 489,132, Aug. 4, 1938 (May 31, 1937).

Profiling and dressing of profile grinding disks. H. LINDNER. Brit. 488,311, July 20, 1938 (Nov. 6, 1936).

Refiner. R. C. BENNER AND A. L. BALL (Carborundum Co.). U. S. 2,124,393, July 19, 1938 (Nov. 14, 1935). A pulp refining engine comprises in combination a metal shell and a lining for the shell consisting of bonded abrasive blocks.

Resin-bonded article. R. S. DANIELS (Bakelite Corp.). U. S. 2,125,893, Aug. 9, 1938 (March 30, 1934). A method of preparing an abrasive article of the soft-bond type from granules having as a bond an alkyd resin comprises mixing the granules with the alkyd resin in powder form, molding the mixture into an article, firing the molded article, when the proportion of resin to granules is about 1 to 7 and the thickness of the article cold-molded under pressures of about 1500 to 2000 lb./sq. in. is about $\frac{1}{2}$ in., at about 85°C for about 16 hr., and continuing at about 135° to 150°C for about 40 to 50 hr., the heating period being in inverse ratio to the temperature and in direct ratio to the thickness, resin content, and porosity of the article.

Segmental abrasive wheels and methods of making. CARBORUNDUM CO. Brit. 487,788, July 6, 1938 (Dec. 30, 1935).

Tool grinder. A. O. SCHAEFER (Atlantic Service Co., Inc.). U. S. 2,124,592, July 26, 1938 (July 24, 1936).

Track-grinding brick. THURE LARSSON (Norton Co.). U. S. 2,124,273, July 19, 1938 (Jan. 9, 1936).

Valve-regrinding device. F. P. HEALY (Van Norman Machine Tool Co.). U. S. 2,125,442, Aug. 2, 1938 (Dec. 23, 1936).

Art and Archeology

Ancient ceramic ware in museums. CHROMPET, M. DEHLINGER, JEAN THUILE, F. MATHIEU, ET AL. *Céram., Verrerie, Email.*, **4** [10] 407–408; [11] 447–48; [12] 491–92 (1936); **5** [1] 27–30; [2] 71–73; [3] 111–12; [9] 307–10; [10] 345–48; [11] 397–401; [12] 431–34 (1937); **6** [1] 24–27; [2] 64–66; [3] 97–104 (1938).—Collections of ancient ceramic ware found in various French museums are described. Illustrated. M.V.C.

Ancient remains and their value in modern commerce. ANON. *Pottery & Glass Record*, **20** [7] 183–84 (1938).—Recent discoveries of ancient pottery and glass are influencing the designs of recent ware; many homes are being furnished in period styles. A.B.S.

Cretan copper. A. CHAPLET. *Cuivre & Laiton*, **11** [226] 305–307 (1938).—Examples of pieces of art of Cu and bronze of Cretan culture of 5000 to 2500 years ago are described and reproduced. They were often combined with terra cotta, ivory, faience, etc. M.H.

Decorative porcelains. JOHN MORSMAN. *Arts & Dec.*, **48** [5] 16–17, 36 (1937).—In Spode's reproductions of old Chelsea figurines, quaintness is emphasized. The colors are vivid, variegated, and highly and smoothly glazed. The Royal Copenhagen ware is distinguished by its luster and unusual clear glaze. The designs are noted for simplicity and naturalism. Illustrated. L.F.M.

Dishes found in tomb. ANON. *Science News Letter*, **33** [19] 305 (1938).—A Syrian tomb of the 18th Century B.C. contained 1045 pieces of pottery. P.G.H.

Elliot bequest of English porcelain and pottery. W. KING. *Brit. Museum Quart.*, **12** [3] 76–78 (1938).—The hundred selected items bequeathed to the British Museum are discussed. The collection, which is the finest in private possession, includes a bagpiper by William Deusbury; this piece is of historic importance as it enables the correct classification of a large number of specimens in other collections. See *Ceram. Abs.*, **17** [9] 297 (1938). A.B.S.

Etruscan vase. F. N. PRYCE. *Brit. Museum Quart.*, **12** [3] 74 (1938).—P. describes an amphora recently acquired by the British Museum, probably made by the "Siren Painter," 510 to 490 B.C. A.B.S.

Pottery from Atchana. ANON. *Brit. Museum Quart.*, **12** [3] 113–14 (1938).—Three pieces of pottery (8th Century B.C.) excavated by L. Woolley at Atchana, North Syria, in 1937 are described. At Tal Brak, M. Mallowan discovered pottery proving that the Sumerian civilization was firmly established here in 3000 to 2000 B.C. A.B.S.

Problems of the present-day art potter. H. R. BACHER. *Bull. Amer. Ceram. Soc.*, **17** [8] 332–33 (1938).

Rare Italian majolica. ANON. *Pottery & Glass Record*, **20** [6] 142–44 (1938).—A brief description of several pieces of antique Italian majolica ware is given. 3 illustrations. A.B.S.

Romano-British pottery in Buckinghamshire. K. P. OAKLEY. *Records of Buckinghamshire;* abstracted in *Notes & Queries*, **173** [21] 361 (1937).—Pottery taken from kilns at Hedgerley is described and illustrated. H.H.S.

Schiff collection at Christie's. ANON. *Pottery & Glass Record*, **20** [6] 148 (1938).—Part of the collection of porcelain and stained glass offered for sale at Christie's is described. See "Early Italian—," *Ceram. Abs.*, **17** [9] 297 (1938). A.B.S.

***Tingere et Aurum* ware.** ANON. *Pottery & Glass Record*, **20** [6] 166 (1938).—A new variety of pottery, *Tingere et Aurum*, is enameled in 17 harmonizing colors, deftly applied. The prints fall and rise from a gold band, giving a costly appearance. A.B.S.

BOOKS

Paestan Pottery. A. D. TRENDALL. Macmillan Co., London. T. gives an account of ancient Greek pottery made and found in Paestum in Southern Italy. A.B.S.

Terra cotta from Afrasiab. C. TREVER. *Marr State Acad. Bull.* [Leningrad], No. 93.—T. describes figures of musicians, mourners, dancing girls, etc., buried on the site of ancient Maracanda, A.D. 1 to 500. A.B.S.

PATENTS

Apparatus for stenciling. J. C. SMITH (Solar Laboratories). U. S. 2,124,011, July 19, 1938 (June 25, 1936).

Applying luminescent colors on bodies consisting of glass, etc. EDMUND GERMER. U. S. 2,123,939, July 19, 1938 (April 11, 1936). A method of applying luminescent material to a body of vitreous material comprises coating the surface of the body with a luminescent material prepared by mixing luminescent substance and a volatile binder, heating the body while unsealed in a pressure of several atmospheres until softening occurs at least of the surface of the body to which the luminescent material is applied, lowering the pressure until any residual volatilized binder is removed, and again applying a pressure of several atmospheres, while continuing the heating whereby to further coalesce the body and the applied material.

Designs for:

Bottle. F. W. LOHSE (T. J. Holmes Co., Inc.). U. S. 110,873, Aug. 16, 1938 (Jan. 10, 1938). GEORGE SMITH, JR. (Olean Glass Co.). U. S. 110,711, Aug. 2, 1938 (June 3, 1938).

Combined bowl and base. E. J. LOESCH. U. S. 110,902, Aug. 16, 1938 (May 23, 1938).

Corner molding strip unit. C. D. LOWRY (Libbey-Owens-Ford Glass Co.). U. S. 110,751 to 110,753, Aug. 2, 1938 (Nov. 15, 1937).

Cup. H. C. KUPPER. U. S. 110,901, Aug. 16, 1938 (Dec. 15, 1936).

Decanter. R. R. KOSTELLOW (United States Glass Co.). U. S. 110,672, July 26, 1938 (April 8, 1938).

Drinking glass. J. E. SPENCE (Hazel-Atlas Glass Co.). U. S. 110,553, July 19, 1938 (May 16, 1938). U. S. 110,912, Aug. 16, 1938 (May 16, 1938).

Glass casserole. M. A. SMITH (McKee Glass Co.). U. S. 110,678, July 26, 1938 (June 7, 1938).

Goblet. R. R. KOSTELLOW (United States Glass Co.). U. S. 110,723, Aug. 2, 1938 (Feb. 16, 1938).

Jar. FRASIER SMITH (Hazel-Atlas Glass Co.). U. S. 110,882, Aug. 16, 1938 (June 25, 1938).

Jug. G. N. KING. U. S. 110,899, Aug. 16, 1938 (March 3, 1938).

Plate. E. C. STYSKEL (M. Seller Co.). U. S. 110,712, Aug. 2, 1938 (April 15, 1938).

Production of lead glazes. HERMANN HARKORT. U. S. 2,125,632, Aug. 2, 1938 (Aug. 22, 1936). A process for producing lead glazes comprises the introduction of the lead into the preparation to be fritted in the form of a lead sulfate-containing substance and the reduction of all of the sulfate during the fritting by means of a powdery metal which is combined with the glaze.

Cements

Cement phosphorescence. M. TRAVNIČEK. *Ann. Physik*, **30** [3] 225–44 (1938).—T. describes a new group of Sorel cements made of MgO, ZnO, or BeO with solutions of chlorides, nitrides, or sulfates of these bases. The setting of these cements is a typical colloidal reaction. If luminescent materials are added, a phosphorescence of almost 2 hr. could be observed; fluorescein and uranin and aesculin and carbazol already respond with daylight, although direct sunlight gives better effects. The color sometimes changes with temperature. Two different emissions, according to radiation, were found: long-wave (daylight) radiation gave a continuous spectrum, and short-wave (ultra-violet) radiation a discontinuous spectrum. M.H.

Correlation of methods for measuring heat of hydration of cement. R. W. CARLSON AND L. R. FORBRICH. *Ind. Eng. Chem., Anal. Ed.*, **10** [7] 382–86 (1938).—The limita-

tions and advantages of each type of calorimeter are pointed out. Illustrated. F.G.H.

Experiences, problems, and future developments of Swiss cement standards. M. Roš. *Schweizer Arch. Angew. Wiss. Tech.*, **2**, 296 (1936); *Chem. Abs.*, **32**, 5175 (1938).—R. discusses the deleterious action of $CaCl_2$ on reinforced concrete, the merits of electrically clinkered cement, the tendency to favor a high-Fe_2O_3 cement, and the relationships between modulus of elasticity and compressive strength of mortar in relation to standardization.

PATENTS

Manufacture of cementitious materials. J. A. Blank and A. J. Blank (Cement Process Corp.). U. S. 2,125,281, Aug. 2, 1938 (Nov. 23, 1932). The process of producing cement comprises burning an intimate mixture of siliceous and lime carbonate-containing materials at a temperature sufficient to calcine the carbonates but insufficient to cause clinkering, hydrating the free-lime component of the resulting mixture, and grinding the mixture in the presence of a small amount of water while maintaining a temperature of at least about 100°C to promote combinations of the lime and siliceous components thereof, the grinding treatment being continued to produce a substantially dry finely divided product capable of hardening when water is subsequently added thereto.

Manufacturing cementitious substance from blast-furnace slag. J. L. Parker and C. H. Starns (Southern Cement Co.). U. S. 2,125,520, Aug. 2, 1938 (April 19, 1937).

Enamel

Alkaline cleaner and wetting agents. F. K. Savage. *Monthly Rev. Amer. Electroplaters' Soc.*, **25** [6] 445–50 (1938); *Bull. Brit. Non-Ferrous Metals Research Assn.*, No. 111, p. 203 (1938).—S. classifies the constituents of alkaline cleaners as (1) soluble inorganic alkalis, (2) insoluble abrasive substances, and (3) colloids. Wetting agents are discussed together with a simple method of estimating wetting power.

American vitreous enameling practice. A. L. Edwards. *Foundry Trade Jour.*, **56**, 378 (1937).—E. outlines the activities of the Porcelain Enamel Institute in America and discusses the tremendous progress of porcelain enameling in the past 20 years. H.E.S.

Arc-welding atmospheres. G. E. Doan and Ardrey M. Bounds. *Welding Jour.* [N. Y.], **17** [6] Supp. 1–4 (1938).—The behavior of CO was worthy of note as no breakdown was indicated. CO, therefore, is promising as a gas for arc-welding atmosphere. W.H.B.

Chemical determination of metallic particles and oxides of iron, nickel, and cobalt in fired ground coats. Karl Kautz. *Jour. Amer. Ceram. Soc.*, **21** [9] 307–11 (1938).

Cleaning and pickling tanks heated by simple economical gas method. J. B. Nealey. *Steel*, **100**, 60, 62, 73 (Feb. 22, 1937).—Gas immersion is an economical way of heating hot solution tanks. Higher over-all efficiencies are obtained. See *Ceram. Abs.*, **16** [7] 199 (1937). H.E.S.

Color matching booth is constructed and illuminated to eliminate shadows. Westinghouse Electric and Mfg. Co. *Steel*, **100**, 64 (May 10, 1937).—Porcelain enamel refrigerator parts are inspected by the "Tunnel of Light" recently installed in the Westinghouse plant. Prior to its installation, rejects were at least 300% higher. H.E.S.

Drawing compounds in relation to cleaning. Carl Johnson. *Enamelist*, **14** [12] 12–13, 47, 49–50 (1937).—The types of materials generally used in the manufacture of drawing compounds are (1) mineral oils, (2) animal and vegetable oils, (3) soaps, and (4) pigments. The finished compound may be composed of any or all of these materials. Mineral oils or compounds of them with special forms of soap are not suitable for drawing parts which are to be enameled due to difficulty of thoroughly cleaning the metal and excessive contamination of the cleaning solution. Animal and vegetable oils can be saponified by an alkaline solution, but because of its conversion into soap it is liable to slow up the cleaning operation. Soaps are broadly classified as water-soluble and water-insoluble soaps. The difference in the various types of soaps is explained, and the difficulties encountered in cleaning soap-drawn metal are indicated. Pigments used in drawing compounds should be soluble in the acid pickling bath. Desirable properties for a satisfactory drawing compound for a vitreous enameling plant are (1) adequate drawing properties, (2) good solubility in alkaline cleaning solutions, (3) rust preventing or retarding properties when left on the drawn ware, (4) effectiveness at moderate or low concentrations in water solutions, (5) ease in mixing an application, (6) freedom from rancidity, odors, and decomposition on aging, (7) freedom from oxidation and hardening on aging when in contact with the metal, and (8) freedom from insoluble or unsaponifiable matter. See "Films—," *Ceram. Abs.*, **17** [8] 271 (1938). E.J.V.

Enameling of panels for architecture. Anon. *Emaillerie*, **6** [5] 7–10 (1938).—The flatness of a paneling chiefly depends on the enameling process. An example is given of the enameling treatment of a plant dining hall. It is possible to keep panels flat by applying a double weight of ground coat at the back of the panel and a cover coat on each side. M.D.

Grinding dry-process enamel and its effect on working properties. M. E. Manson. *Jour. Amer. Ceram. Soc.*, **21** [9] 316–19 (1938).

Impact resistance of enameled sheet iron. G. Galbiati. *Emaillerie*, **6** [6] 7–12 (1938).—In checking the impact resistance of enameled sheet iron with the variable thickness of a given enamel, G. noticed that this resistance was too low. He succeeded in increasing the impact resistance for a given enamel thickness by replacing part of the tin oxide by ZrO_2SiO_2, thus increasing the specific gravity of the enamel finish. See *Jour. Amer. Ceram. Soc.*, **19** [10] 298 (1936). M.D.

Importance of temperature control in vitreous enameling. H. Astbury. *Foundry Trade Jour.*, **56**, 446–48 (1937).—A. describes and illustrates the various apparatus available for controlling and measuring temperatures encountered in the process of enameling, including the mercury thermometer, indicating thermometer, thermocouple, millivoltmeter, radiation pyrometer, and various automatic controls such as the automatic gas regulator, thermocouple regulators, valve operating gear, etc. H.E.S.

Mill additions: Setting-up agents. M. J. Bahnsen. *Emaillerie*, **6** [5] 13–19 (1938).—Gums which have been used as floating agents are now recommended whenever a large amount of brushing is necessary. The various kinds of salt used as setting-up agents, such as borax, magnesium carbonate, soda ash, etc., are reviewed in each case when they should be used. Flocculating agents are always added at the start of the milling operation. Borax is the most commonly used in sheet-iron ground coat; magnesium carbonate or sodium nitrite are added whenever necessary; ammonium carbonate sometimes replaces borax. Magnesium carbonate is used as flocculating agent in cover coat enamels. When dipping, larger amounts of magnesium carbonate are added, supplemented if necessary by Epsom salts or calcium chloride solution at the dipping tank; super-opaque enamels require up to 0.375% magnesium carbonate as mill addition. In the case of acid-resisting enamels, a larger amount of setting-up salt must be added. In cast iron enamels, it is advantageous if the setting-up agent is also a rust inhibitor. Sodium nitrite is often used for this purpose. When too much set has been given to an enamel it can be cut by adding small amounts of sodium silicate. **Opacifiers.** *Ibid.*, [6] 13–21.—After discussing the scientific standards for opacity in enamels, B. briefly surveys the various opacifying materials generally used. The efficiency of a given amount of opacifier is larger in opaque than in super-opaque enamels, the gain in opacity of a given enamel being larger for the first 1% of

opacifier added. With super-opaque enamels, a maximum opacity is reached with little opacifier. Opacity increases with increasing weight of enamel applied. Several types of reflectometer have been designed, but most enameling plants now use the Hunter reflectometer. See *Ceram. Abs.*, **17** [9] 300 (1938). M.D.

Mill-room practice. B. B. KENT. *Foundry Trade Jour.*, **56**, 124–26 (1937).—Detailed standards are desired in the porcelain enameling industry both from the standpoint of testing of the finished product and control of the various processes in production. H.E.S.

Mill-room practice. B. B. KENT, J. H. GRAY, H. BRADLEY, T. J. MCARTHUR, H. JUKES, W. E. HILLER, AND W. H. WHITTLE. *Foundry Trade Jour.*, **56**, 376–78 (1937).—Mill-room practice is discussed from the standpoint of mill speeds, mill design, aging of enamels, fineness standards, and rapidly run mills. H.E.S.

Open-hearth iron taps a new market. C. S. PEARCE. *Metal Progress*, **33** [1] 49–53 (1938).—The long-discussed idea of metal houses is becoming a reality. In ordinary residences optimum results as to cost, durability, and finish are possible with the use of enameled iron panels. Early attempts to introduce enameled iron for buildings were not successful, although a house built in Germany in 1893 still stands. In the twenties enameled iron came into wide use for roofing sheets. Complete buildings are today designed for the use of enameled sheet as the finished surface, and many commercial buildings are being remodeled with its aid. Porcelain enamel is also used in special fields of architecture; blocks of artificial stone faced with enameled panels are finding increased application. P. discusses the advantages, disadvantages, and problems connected with the use of enameled panels in building construction. Porcelain enamel on sheet steel has not yet been made with waviness eliminated, although the effect has been mitigated by using nonsagging (heavy gage) metal and low-firing ground coat. F.P.P.

Porcelain cables. ANON. *Brit. Clayworker*, **47** [554] 95 (1938).—A new type of porcelain cable has been developed in Germany. Bare metal conductors are placed inside a porcelain pipe which simultaneously acts as insulation and as a sheath. R.A.H.

Porcelain enamel finish. ANON. *Emaillerie*, **6** [5] 11 (1938).—Photographs of various porcelain enameled appliances show the value of the finish. M.D.

Porcelain enamel protects cast-iron pumps against corrosion and sand wear. ANON. *Steel*, **100**, 52–54 (Feb. 8, 1937).—The problem of electrolysis and sand cutting has been successfully solved by the application of porcelain enamel finish to impellers, bowls, and runners for deep well pumps. H.E.S.

Progress in welding in the first half of 1937. W. LOHMANN. *Stahl & Eisen*, **57**, 1051–55 (1937); translated in *Welding Jour.* [N. Y.], **17** [1] Supp. 20–24 (1938).—L. reviews the literature, which is chiefly American. 32 references. L.R.B. + W.H.B.

Protective gas installations for bright annealing of iron, steel, and nonferrous metals. W. POHL. *Gas- & Wasserfach*, **81** [22] 374–82 (1938).—The physicochemistry of bright annealing is explained, and the production of protective gases (CO, CO_2, H_2, H_2O, CH_4, etc.) and their mixtures is described. Eight references. M.H.

Random experiments on enamel adherence. KARL KAUTZ. *Jour. Amer. Ceram. Soc.*, **21** [9] 303–307 (1938).

Reply to Staley's discussion of "Critical analysis of statements and experiments on the adherence of sheet-steel ground coats." KARL KAUTZ. *Jour. Amer. Ceram. Soc.*, **21** [9] 311–15 (1938); see *ibid.*, **20** [4] 121–24 (1937).

Sandblasting as applied to the vitreous enameling process. H. WHITAKER. *Proc. Inst. Brit. Foundrymen, Advance Paper*, No. 640, 8 pp. (June, 1938); *Bull. Brit. Non-Ferrous Metals Research Assn.*, No. 111, p. 203 (1938).

Use of the water elutriator in addition to screen tests in determining fineness distribution of milled enamel. L. A. LANGE AND R. L. FELLOWS. *Jour. Amer. Ceram. Soc.*, **21** [9] 297–303 (1938).

Vitreous enameling in Germany. H. J. KARMAUS. *Foundry Trade Jour.*, **56**, 11–12 (1937).—Vitreous enameling in Germany dates back to the latter half of the 18th Century. Since the World War, however, enormous expansions have been made in the industry. Expensive borax is eliminated by the use of a finely powdered alkali borosilicate glass. In dry cooling, the enamel, instead of being quenched in water, is passed from the frit furnace between cooled rolls. Mat finishes are produced by extensive use of opacifiers, in particular, antimony oxide, kaolin, magnesium oxide, etc., in the frit and in the mill. Many new applications of vitreous enamel products have been made such as for motorcar exhaust pipes and elbow pipes, light reflectors, brewery tanks, and railway carriages for the tropics. See "Mechanical—," *Ceram. Abs.*, **17** [8] 271 (1938). H.E.S.

Vitreous enameling industry and the Institute of Vitreous Enamelers. W. H. WHITTLE. *Foundry Trade Jour.*, **56**, 40–42 (1937).—W. surveys the enameling industry including historical details. Production in 1934 in the bath, hollow-ware, signs, and electric and gas appliance industries as well as the distribution of enameling works in the United Kingdom is discussed. H.E.S.

Welding chromium steels (up to 10% Cr). Review of literature to July 1, 1937. W. SPRAGUEN AND G. E. CLAUSSEN. *Welding Jour.* [N. Y.], **17** [7] Supp. 1–39 (1938).—Research problems are suggested. 154 references. W.H.B.

PATENTS

Enamel. SOCIETÀ ELETTROTECNICA CHIMICA ITALIANA. Fr. 823,125, Jan. 14, 1938; *Chem. Abs.*, **32**, 5596 (1938).—An enamel or glaze for application to metals, *e.g.*, resistance spools, consists of Cr_2O_3 5 to 10, PbO 7 to 14, and SiO_2 at least 35%. The Cr_2O_3 may be replaced by Al_2O_3 or ZrO_2. B_2O_3 may also be present.

Enameling of iron. I. G. FARBENINDUSTRIE AKT.-GES. AND EISENWERK KAISERS-LAUTERN. Brit. 488,580, July 20, 1938 (Jan. 11, 1936).

Enamels and glazes. IGNAZ KREIDL. Austrian 153,054, April 11, 1938; *48c.; Chem. Abs.*, **32**, 5596 (1938). See Brit. 313,411 (*Ceram. Abs.*, **8** [10] 712 (1929)).

Manufacture of enamel. WALTER HEIMBERGER (Firmitana Metallkeramik G.m.b.H.). U. S. 2,127,116, Aug. 16, 1938 (Oct. 4, 1935). The method of dry cooling fused enamel comprises rolling out the hot fused enamel between artificially cooled surfaces rotating at different speeds.

Means for measuring the thickness of enamel, paint, etc., coatings applied to iron bodies. RADIATION, LTD., H. J. YATES, AND A. R. BENNETT. Brit. 489,030, Aug. 4, 1938 (Dec. 1, 1937).

Oven with continuous conveyer, particularly an enamel firing oven. CARL THIEL. Ger. 656,618, Jan. 27, 1938 (May 8, 1936); VI/*48c.* 7. In an oven with a firing chamber in which the combustible material is continuously kept in motion, the roof of the firing chamber is supported by columns which act as a support for the U-shaped conveyer and through which preheated air can be forced. The heating elements are arranged between the carrying columns, the material of which has greater heat permeability. D.A.B.

Glass

Atomic constitution of glass. FRANK MATOSSI. *Z. Physik. Chem. Unterricht*, **51**, 71–76 (1938); *Chem. Abs.*, **32**, 5167 (1938).—Structural schemes and X-ray spectra for glasses of different compositions and treatments are shown in the diagrams, and references to several important papers are given. See "Infra-red—," *Ceram. Abs.*, **17** [4] 138 (1938).

Character of the transformation point. E. JENCKEL. *Glastech. Ber.*, **16** [6] 191–95 (1938).—A volume-temperature study was carried out on vitreous selenium and colophony, previously studied by Tammann and Kohlhaas (*Ceram. Abs.*, **8** [12] 872 (1929)). Volume changes were followed on the capillary of a dilatometer. Tammann found a break in the volume-temperature curves for both

glasses at approximately 30°C. With sufficient time to reach equilibrium, linear curves result. With lower temperatures, the time necessary is greatly increased. J. concludes that at least down to below 23°C the so-called transformation point is only a freezing-in temperature. The freezing-in of a glass is not bound to a definite viscosity, as viscosity is also a function of the cooling rate. J. gives curves for volume, expansion, and freezing-in temperature against molecular per cent for the binary system B_2O_3–SiO_2; these show breaks indicating the same compound formation at approximately 42 molecular per cent B_2O_3. **Discussion.** E. BERGER AND A. SMEKAL. *Glastech. Ber.*, **16**, 195–98 (1938). J.F.H.

Chemist at work. ROY I. GRADY AND JOHN W. CHITTUM. **V, Chemical research in the glass industry.** W. J. ARNER. *Jour. Chem. Education*, **15** [4] 175–76 (1938).—A. describes the engineering difficulties and engineering problems connected with the development of cellulose acetate plastic bonded safety glass. **XIX, Chemist in the glass industry.** S. R. SCHOLES. *Ibid.*, [6] 283–85 (1938).—S. describes the duties of a chemist in a glass plant of moderate size. Analytical and research procedure is described in relation to the various steps in the manufacture of glassware. A rating and a discussion of the personal characteristics needed by the chemist to succeed in his field are given. P.G.H.

Developments in American glass manufacture: II, 1931 to 1938. ALEXANDER SILVERMAN. *Bull. Amer. Ceram. Soc.*, **17** [8] 335–38 (1938); for Part I see *Ceram. Abs.*, **10** [10] 690 (1931).

Dielectric constant and dipole losses of glasses at high frequencies. W. HACKEL. *Ann. Physik*, **29** [1] 63–80 (1937).—Measurements were made on Schott glasses in the range from 1200 m. to 10 m. The conductivity increases proportionally with the frequency, although, theoretically, it should increase with the square of the frequency. The difference is explained by dipole losses similar to those found in very viscous polar liquids. Exhaustive tests are described in detail. M.H.

Elastic after-effect and its relation to the optical after-effect. H. MUSSMANN. *Ann. Physik*, **31** [2] 121–44 (1938).—Experiments with glass and celluloid show that proportionality between elastic after-effect and the tension exerted exists in glass up to fracture and in celluloid up to the elastic limit. The after-effect in celluloid increases linearly with temperature almost up to the softening point. The relation between elastic and optical behavior in celluloid can be expressed by $\gamma = a\sigma + b\epsilon$, where γ = the birefringence, σ = the tension, and ϵ = the elongation; a and b are material constants. The formula is explained by Prandtl's theory. M.H.

Fluorescence of glasses. WOLDEMAR WEYL. *Sprechsaal*, **70** [46] 578–82 (1937).—W. describes the nature of fluorescence and phosphorescence phenomena and explains the way in which these phenomena may be used in the study of the constitution of glasses and solutions. Cations which do not fluoresce in watery solutions can become fluorescent in glass. The small "solving" of cations in glass permits the emission of a part of the absorbed light. The fluorescence of uranium, some rare earths, vanadium, manganese, and copper is described. In connection with the phosphorescence of uranium glasses, W. shows that, in general, vitrified bodies may phosphoresce. Organic glasses show that the formation of crystal nuclei or crystalline structure does not result from the capability to phosphoresce. The fluorescence phenomena of silver glasses are discussed in detail; atomic silver is luminescent. Atomically dispersed silver can be obtained in glass by reducing the silver ions present to metallic silver with hydrogen at 100° to 150°C. Those silver atoms which are imbedded in a crystalline lattice (NaCl, KCl) or adsorbed by a lattice (Al_2O_3) are fluorescent. With increasing temperature, an aggregation takes place whereby the silver atoms no longer deposit with the fluorescent crystal nuclei. This extinction of fluorescence produces a "disarrangement" of fluorescence color. The silver fluorescence can therefore be used as indicator for determining the place exchange in glasses and crystals and the rate of diffusion of hydrogen through glass. The aggregation of silver atoms with crystal nuclei forms the basis for the appearance of color (silver yellow). On the same basis, the fluorescence of cadmium sulfide glasses can be explained. Cadmium sulfide is fluorescent in molecular dispersion. With increased aggregation, the fluorescence color is shifted and then disappears; crystallized cadmium sulfide does not fluoresce. The monomolecular distribution of cadmium sulfide may occur in glass (yellow filter glass) or the molecules may be individually adsorbed by another medium (Al_2O_3, celluloid). M.V.C.

Glass for building construction. ANON. *Eng. News-Record*, **116**, 459 (1936).—Construction details and results of tests made on the glass blocks are discussed. B.C.R.

Glassblower's work (free-hand, blown). B. MAUDER. *Glastech. Ber.*, **16** [6] 198–203 (1938). J.F.H.

Hollow glass brick. B. LONG. Read before Congr. Chim. Ind., 17th Congress, Paris, 1937; reprinted in *Glaces & Verres*, No. 54, pp. 2–6 (1938); *Sklářské Rozhledy*, **14**, 157–64 (1937); see *Ceram. Abs.*, **17** [7] 248 (1938). E.P. + R.W.D.

Metallurgical progress. ANON. *Mill & Factory*, **21** [5] 56–61 (1937).—Abundance of light, cleanliness, and temperature and dust control are obtained by using Carrara glass, glass brick and blocks, and plate glass in the Firth-Sterling Steel Co. plant, McKeesport, Pa. Through these materials the plant has been soundproofed to the extent of 85%. Illustrated. D.A.B.

Molecular refractions and molecular volumes of glasses. W. BILTZ, F. WEIBKE, AND L. FRAEGER. *Glastech. Ber.*, **16** [4] 131–33 (1938).—The Lorenz-Lorentz formula was used in calculating molecular refractions. Recent data (Faick and Finn, Bureau of Standards) on Na_2O-CaO-SiO_2 glasses show an error of less than 0.5% between calculated and found values. Calculations of molecular volume, molecular refraction, and index for the system Na_2O–B_2O_3 agree with data of Wulff and Majumdar within an error of about 0.1%. Molecular volume data on Na_2O–CaO–SiO_2 compositions (Enss, Lai and Silverman, Keppler and Ippach) agree with calculations within 1 to 2%. Molecular volumes for the system Na_2O–SiO_2 are plotted against the total molecular percentage SiO_2. The curve closely follows a curve constructed from the calculated values for Na_2SiO_3, $Na_2Si_2O_5$, and SiO_2 up to the composition $Na_2Si_4O_9$. Beyond this point, there is a deviation of 1 to 2% such that experimental values are less than calculated. From the point of view of Warren and Loring (*Jour. Amer. Ceram. Soc.*, **18** [9] 269–76 (1935); **21** [7] 259–65 (1938)), there are two types of O_2 linkages in glass, one joining Si atoms, the other alkali atoms. Values of the refraction and volume increments for the oxygen joining Si atoms, calculated from various compositions, are in good agreement. Similar calculations for oxygen binding alkali ions show a greater value which increases with decreasing charge on the ion joined and increases with ionic radius. Calculated refractions are in agreement with X-ray data and stereochemical considerations if a "packing effect" is taken into account. J.F.H.

Potash in the glass industry. A. N. FINN. *Ind. Eng. Chem.*, **30** [8] 891–92 (1938).—The use of potassium carbonate and nitrate by the American glass industry is confined almost exclusively to the manufacture of the better grades of table, decorative, and illuminating glassware, colored glasses, and ophthalmic and optical glass. Potassium oxide can not be substituted for sodium oxide in many commercial glasses because of its effect on the working properties of the glass. Within limits, the purity of the potassium compounds is of less importance than freedom from coloring oxides (such as those of iron), provided the potassium oxide content is constant and definitely known. F.G.H.

Refractive indices of some glasses in the ternary system K_2O-$4SiO_2$–Fe_2O_3–SiO_2. GEORGE T. FAUST AND ALBERT B. PECK. *Jour. Amer. Ceram. Soc.*, **21** [9] 320–24 (1938).

Spectral absorption of neodymium glasses. K. ROSENHAUER AND F. WEIDERT. *Glastech. Ber.*, **16** [2] 51–57 (1938).—Measurements were made with a Kunig-Martens spectrophotometer. Absorption curves are given for a

series of neodymium glasses containing Rb, K, Na, Li, Mg, Ca, Zn, Sr, Cd, and Ba. The results show that neodymium is a satisfactory indicator for studying the constitution of glasses. The sharpness of its band lying in the orange region is a measure of the electric fields arising from the molecules. It is necessary to distinguish between glasses containing only small amounts of Nd and those in which the Nd itself takes an essential part in glass formation. If greater lattice distortion is brought about by increasing the alkali content, the structure of the absorption bands fades. With the alkalis, distortion increases with decreasing atomic radius. The same holds for the bivalent metals. The results are in agreement with those of Weyl that not only atomic radii but also outer electronic configurations have a strong effect on distortions. The distortion effect is related to devitrification in such a way that in a group of glasses, those tending to devitrify easily show faded absorption bands. An increasing distortion is noticed with increasing neodymium, so that Nd-rich glasses show little structure in the absorption bands. A decrease in ability to fluoresce parallels this distortion. 13 references. See "Chemistry—," *Ceram. Abs.*, **16** [6] 170 (1937). J.F.H.

Strain in glass: II. NIUTA WINTER-KLEIN. *Rev. Optique*, **16**, 361–85 (Nov., 1937); abstracted in *Science Abs.-A*, **41** [486] 526 (1938).—From a study of the passage of glass from the α- to β-variety, W. concludes that there is a region rather than a point of transformation. Samples of each of the two varieties when heated to a chosen temperature each tend toward the same state of equilibrium. A rapid method of annealing is suggested. A temperature can be found at which the transformation takes place instantaneously. The indices of refraction corresponding to the various states were also investigated. See *Ceram. Abs.*, **17** [4] 136 (1938). H.K.R.

Tempering glass with air. EM. CHERON. *Bull. soc. ind. Rouen*, **65**, 142–49 (1937); *Chem. Abs.*, **32**, 2304 (1938).—C. reviews the theory of the tempering of glass and discusses modern industrial methods. Several diagrams of apparatus are given.

Viscosity and electrical conductivity of fused salts and glasses. K. S. EVSTROP'EV. *Izvest. Akad. Nauk S.S.S.R.*, **1937**, No. 3, pp. 359–74 (in English 375); *Chem. Abs.*, **32**, 5272 (1938).—On the basis of data found in the literature on viscosity of various liquids, E. concludes that change of viscosity with temperature in unassociated liquids (BuOH) follows the Frenkel-Andrade equation $\eta = Ae^{\alpha/T}$, where A and α are constants, and in associated liquids (H_2O, molten glass), it follows Waterton's equation $\ln\eta = A' + (\alpha'/T)e^{a/T}$, where A', α', and a are constants. Change of electrical conductivity with temperature in fused salts follows the equation $x = Be^{\beta/T}$, where B and β are constants, and in associated liquids (molten glass), it follows the equation $\ln x = B' - (\beta'/T)e^{b/T}$, where B', β', and b are constants. The relations between x and η, in salts and glasses, is expressed by the equation $x^n \cdot \eta$ = constant, where n is a large-number constant. See "Electrical —," *Ceram. Abs.*, **15** [7] 202 (1936).

Weaving glass. ANON. *Can. Machinery*, **48** [9] 58 (1937).—Spinning and weaving of glass into fine cloth which is nonconducting and fireproof are discussed. Brittleness of the glass is removed by weaving in oil. The material is finding use as a material for electric tape. D.A.B.

X-ray analysis of the structure of glasses. A. A. LEBEDEV. *Izvest. Akad. Nauk S.S.S.R.*, **1937**, No. 3, pp. 381–88 (in English 388–89); *Chem. Abs.*, **32**, 5272 (1938).—An X-ray investigation of the structure of Na_2O-SiO_2 glasses containing less than 50 mol. % Na_2O reveals the presence of cristobalite, either alone or together with tridymite, and of Na_2O-SiO_2, the relative amounts of each depending on the ratio Na_2O:SiO_2. Size of the crystals varies between 7 and 15Å and depends on the thermal treatment of the glass. The X-ray results are confirmed by determining changes in n in the glass heated to 300°.

BOOK

Physico-Chemical Bases of the Glass Industry. P. GILARD AND L. DUBRUL. Dunod, Paris, 1937. 223 pp., 45 figs. Price 35 F plus postage. The physicochemical bases on which the glass industry depends are simply but completely given. The manner in which the components of glass influence its properties is pointed out, and a study is made of the defects of glass, the means of avoiding them, and the different techniques of glass decoration. The book is of value to glass technicians as the numerical information and practices given enable them to avoid losses of time in research and aid in solving daily problems which confront them.

PATENTS

Apparatus for:

Continuous drawing of glass tubes of a larger diameter. O. KRÜGER. Ger. 660,345, April 28, 1938 (Nov. 4, 1936); VI/32*a*. 24.02. An air throttle device is located inside the glass tube which is drawn off by a revolving blowpipe in an almost horizontal position. D.A.B.

Drawing glass sheets. N. V. HOLLANDSCHE MIJ. VOOR DE VERVAARDIGING VAN GLAS. Fr. 823,398, Jan. 19, 1938; *Chem. Abs.*, **32**, 5594 (1938).

Drawing sheets of glass. FRAZIER-SIMPLEX, INC. Fr. 823,598, Jan. 22, 1938; *Chem. Abs.*, **32**, 5594 (1938).

Fabrication of glass articles. F. L. O. WADSWORTH (Ball Bros. Co.). U. S. 2,124,091, July 19, 1938 (Jan. 18, 1935).

Feeding charges of molten glass. D. E. SHARP. U. S. 2,126,351, Aug. 9, 1938 (Feb. 27, 1936).

Making threads of glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Fr. 823,535, Jan. 21, 1938; *Chem. Abs.*, **32**, 5594 (1938).

Producing sheet glass. W. T. HAIGHT (Libbey-Owens-Ford Glass Co.). U. S. 2,125,914, Aug. 9, 1938 (July 28, 1934).

Applying binding materials. D. C. DRILL, C. L. WHITENACK, AND J. H. GREGORY (American Rock Wool Corp.). U. S. 2,124,768, July 26, 1938 (July 5, 1935). Method of applying a binder made of a plurality of mutually chemically reactive substances to mineral wool fibers in the production of mineral wool batts.

Charging rapidly rotating furnaces, particularly for melting glass. GEORG ZOTOS. Ger. 656,891, Feb. 3, 1938 (April 23, 1935); VI/32*a*. 5. The rapidly rotating furnace is charged by means of a charging ladle, the charge being prepared over the long surfaces of the melting chamber. D.A.B.

Compositions of matter. MARTIN MUELLER-CUNRADI, MICHAEL OTTO, WALTER DANIEL, AND ROBERT WERNER (I. G. Farbenindustrie A.-G.). U. S. 2,124,235, July 19, 1938 (July 3, 1934). Safety glass comprises a plurality of glass sheets combined with each other by means of a layer essentially comprising an isobutylene polymer having a molecular weight of at least about 1000.

Cutting glass sheets. J. J. HOPFIELD (Libbey-Owens-Ford Glass Co.). U. S. 2,125,922, Aug. 9, 1938 (Sept. 26, 1935).

Drawing off molten glass from rapidly rotating furnaces. GEORG ZOTOS. Ger. 656,892, Feb. 3, 1938 (April 23, 1935); VI/32*a*. 5. The molten material is drawn off by means of a device which pulls the molten glass from the furnace in a direction counter-current to the motion of the furnace, through a groove or channel. D.A.B.

Drawing sheet glass. UNION DES VERRERIES MÉCANIQUES BELGES SOC. ANON. Brit. 488,121, July 13, 1938 (Feb. 17, 1936).

Electric furnace for the melting of glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Brit. 489,207, Aug. 4, 1938 (Aug. 14, 1936).

Electric lamp. IRVING H. VAN HORN (Canadian General Electric Co., Ltd.). Can. 375,453, Aug. 2, 1938 (Oct. 31, 1934). G.M.H.

Flask stopper for reagent bottles. C. SCHANZ. Ger. 655,656, Dec. 30, 1937 (Oct. 18, 1934); IX/30*b*. 21.05. D.A.B.

Forming glass-to-metal seals. V. L. RONCI (Bell

Telephone Laboratories, Inc.). U. S. 2,125,315 and 2,125,316, Aug. 2, 1938 (Feb. 4, 1936).

Forming hollow glass articles. W. P. ZIMMERMAN AND M. K. HOLMES (Owens-Illinois Glass Co.). U. S. 2,127,150, Aug. 16, 1938 (Oct. 31, 1936).

Glassmakers' blowpipe. L. STOESS. Ger. 655,596, Dec. 30, 1937 (Nov. 7, 1935); VI/32*a*. 7. A glassmaker's blowpipe is designed with a renewable end piece of nonrusting and nonfusing steel and a pipe shaft of lightweight metal, particularly light aluminum alloy. D.A.B.

Glass-tank wall. J. H. MCKELVEY AND J. W. ROGERS (Laclede-Christy Clay Products Co.). Can. 375,349, July 26, 1938 (March 8, 1937). G.M.H.

Glass-tube cutter. WILLIAM AUCKLAND. U. S. 2,125,864, Aug. 9, 1938 (March 24, 1936).

Glassworking machine. H. N. HALVERSEN (Kimble Glass Co.). U. S. 2,125,017, July 26, 1938 (June 28, 1935).

Hardening glass objects. CORNING GLASS WORKS. Ger. 655,542, Dec. 30, 1937 (Feb. 11, 1936); VI/32*a*. 30. The glass is rapidly cooled and then reheated before hardening. D.A.B.

Machine for cutting spectacle lenses, watch glasses, etc., in accordance with a pattern or former. A. T. JORDAN AND P. LEVER. Brit. 487,611, July 6, 1938 (Feb. 1, 1937).

Making glass threads and wool by centrifugal process. N. V. MIJ. TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Ger. 649,009, July 29, 1937 (Aug. 21, 1936); *Jour. Soc. Glass Tech.*, **22** [90] A95 (1938). Addition to Ger. 539,738, VI/32*a*. 25 (*Ceram. Abs.*, **12** [4] 152 (1933)).—The glass threads thrown off by the revolving wheel are caught while still plastic on a series of rods radiating from the wheel to form a stationary extension of its surface.

Making mineral wool. E. R. POWELL (Johns-Manville Corp.). U. S. 2,126,411, Aug. 9, 1938 (April 17, 1934).

Making rock wool preparations. W. E. CARSON. U. S. 2,127,287, Aug. 16, 1938 (July 2, 1936).

Manufacture of fibers from glass and other materials. N. V. MIJ. TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Brit. 487,648, July 6, 1938 (Oct. 23, 1936).

Manufacture of glass threads, etc. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Fr. 823,361, June 22, 1937; *Chem.-Ztg.*, **62** [11] 103 (1938). D.A.B.

Manufacture of highly polished building elements, *e.g.*, window plates. F. AND P. GRIBI. Swiss 192,796, Sept. 15, 1936; *Chem.-Ztg.*, **62** [6] 65 (1938). D.A.B.

Mechanical insertion of glass articles into annealing furnace. UNITED GLASS BOTTLE MANUFACTURERS, LTD. Ger. 660,248, April 28, 1938 (May 27, 1935); VI/32*a*. 34. Glass articles are inserted into the annealing furnace by a pushing plate which is attached to a rod hanging down from a mobile carrying frame. At regular intervals a series of bottles on their sides are pushed under the entrance of the furnace by the continuous feeder. The angular position of the pushing plate in relation to that of the rod hanging down from the frame is adjustable around an axis running in the same direction as the pushing plate. D.A.B.

Method and apparatus for feeding glass. W. L. MCNAMARA (Capstan Glass Co.). U. S. 2,125,079, July 26, 1938 (Jan. 19, 1935).

Method and apparatus for producing hollow glass bodies. W. DUDEK, K. LEHNIGK, AND H. POPELLA. Brit. 488,603, July 20, 1938 (Feb. 18, 1937).

Method and apparatus for tempering glass. B. E. MOUNIER. Fr. 829,348, Feb. 18, 1937; *Chem.-Ztg.*, **62** [55] 498 (1938). D.A.B.

Method and apparatus for tempering glass. PRODUITS VITRIFIÉS ST.-CHRISTOPHE S. A. Fr. 829,655, Feb. 27, 1937; *Chem.-Ztg.*, **62** [55] 498 (1938). D.A.B.

Molding hollow bodies of glass. BERNHARD ENGELS. U. S. 2,123,937, July 19, 1938 (May 24, 1935).

Nonrefillable bottles, etc. C. W. JOHNSON. U. S. 2,125,790, Aug. 2, 1938 (Sept. 11, 1935).

Nonrefillable stopper. C. W. JOHNSON. U. S. 2,125,791, Aug. 2, 1938 (Dec. 20, 1935).

Packing glass fibers. N. V. MIJ. TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Brit. 488,675, July 27, 1938 (June 30, 1936).

Preparation of the point of separation in ampoules. OSKAR SONTAG. Ger. 656,851, Feb. 3, 1938 (June 29, 1936); VI/32*a*. 27. A stricture, serving later as a point of separation, is produced on the filling tube, shaped, and joined to the body of the ampoule. D.A.B.

Press for the manufacture of multilayer shatterproof glass. ADOLF KÄMPFER. Ger. 656,895, Feb. 3, 1938 (Sept. 21, 1935); XII/39*a*. 17.50. The press is provided with a checkstop for the mobile press ram and a compressible frame (forming an enclosed evacuated receptacle for the material being joined during the pressing process) arranged between the press rams. The tap rod connected with the mobile press ram projects through the fixed beams which lie outside of the path of motion of the mobile press ram, and the length of the ram is adjustable for the purpose of inducing further pressure caused by atmospheric pressure during the evacuation of the frame. D.A.B.

Process and furnace for making mineral wool. E. R. POWELL (Johns-Manville Corp.). U. S. 20,828, Aug. 16, 1938 (March 3, 1938); reissue of original U. S. 2,057,393 (*Ceram. Abs.*, **16** [1] 19 (1937)).

Production of glass receptacles with wide bodies and tubular necks such as ampoules. JACOB DICHTER. Ger. 656,302, Jan. 20, 1938 (Jan. 26, 1934); VI/32*a*. 27. Ampoules with wide bodies and tubular necks are formed by attaching a narrow neck to the wide tube forming the body of the ampoule. The tube of the body is formed without drawing off of the end piece, and by using a tool, the stricture is formed approximating the cross section and wall strength of the neck. The neck is then fused to this stricture and the union is blown, if desired. D.A.B.

Regulating the temperature of rolling parts, etc., coming in contact with heated glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Ger. 656,850, Feb. 3, 1938 (July 14, 1936); VI/32*a*. 18. During the rolling of the glass, wire brushes are brought into contact with the glass; by these brushes, the desired amount of heat of the rolling can be diminished or increased. D.A.B.

Safety glass. H. K. NASON (Monsanto Chemical Co.). U. S. 2,126,028, Aug. 9, 1938 (Oct. 11, 1937). A safety glass includes in combination a plurality of sheets of glass bonded together through the medium of a layer of resinous polyvinyl acetal in admixture with a plasticizer consisting of tributyl citrate.

Safety glass heating method. JAMES W. KAMERER (Pittsburgh Plate Glass Co.). Can. 374,749, June 28, 1938 (March 1, 1937). G.M.H.

Safety glass manufacture. BROOK J. DENNISON (Pittsburgh Plate Glass Co.). Can. 374,750, June 28, 1938 (March 25, 1937). Can. 374,751, June 28, 1938 (June 25, 1937). G.M.H.

Structural glass. F. W. PRESTON. U. S. 2,126,574, Aug. 9, 1938 (Nov. 23, 1935). The combination with structural framework for buildings of vitreous panels which are of generally channel form, means for connecting the panels to the framework, means for connecting and sealing the longitudinal edges of adjacent panels, the channels being outwardly exposed and edge portions thereof extending laterally in directions generally parallel to the plane of the panels, and filler blocks interposed between the edge portions and the adjacent framework at points adjacent to the ends of the panels.

Tempering of glass. PILKINGTON BROS., LTD. Brit. 487,822, July 6, 1938 (Dec. 22, 1936). Brit. 488,602, July 20, 1938 (Dec. 22, 1936).

Treatment of glass threads. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Fr. 829,393 and 829,394, Nov. 17, 1937; *Chem.-Ztg.*, **62** [55] 499 (1938). D.A.B.

Vehicle headlight. WILHELM HONING (Canadian General Electric Co., Ltd.). Can. 375,455, Aug. 2, 1938 (Jan. 16, 1935). G.M.H.

Weir for glassmaking tank. VERGIL MULHOLLAND (Hartford-Empire Co.). U. S. 2,127,087, Aug. 16, 1938 (Nov. 4, 1935).

Structural Clay Products

Ceramic materials of old Louisiana buildings. RICHARD KOCH. *Bull. Amer. Ceram. Soc.*, **17** [8] 329–31 (1938).

Fused ceramic material for use as riprap. D. A. BUZZELL. *Eng. News-Record*, **120** [22] 787 (1938).—Tests show that fused ceramic blocks will make a satisfactory protection for earth fill. Ordinary commercial brick are fused together in the kiln and then split apart with one dimension equal to the thickness of the riprap layer. This material compares favorably with quarry stone, and, except when the latter may be obtained nearby, is almost as economical. B.C.R.

Improvement of stiff-mud clays through p_H control. G. J. BARKER AND EMIL TRUOG. *Jour. Amer. Ceram. Soc.*, **21** [9] 324–29 (1938).

Silicate formation in lime mortars and sand-lime brick. F. HUNDESHAGEN. *Zement*, **26** [38] 628–31 (1937).—H. has developed a process of mineralogical determination based on the use of organic coloring agents. In lime mortars, the silicate formation is dubious, even in the case of very old mortars, and is without practical importance. Sand-lime brick contain $100SiO_2$ and $10CaO$; they are exposed to steam pressure (120 to 140 lb./sq. in.) for 8 to 10 hr. The color method shows a very fine layer of active silica hydrate on quartz grains with adjacent layers of colloidal lime silicates of an increasing basical character. F.E.V.

BOOKS

Brickmaking Cyclopedia (Ziegelei-Lexikon). Buchhandlung Gustav Fock G. m. b. H., Leipzig, 1938. Complete in 18 to 20 monthly issues. Price 3.60 Rm each. The book was compiled by well-known brickmaking experts. It is practically the only book on brickmaking showing the recent progress which has been made.

Thermal Conductivity of Building Materials. FRANK B. ROWLEY AND AXEL B. ALGREN. University of Minnesota. 134 pp. Price paper $1.00, cloth $1.50. Reviewed in *Science News Letter*, **32** [851] 80 (1937).—The insulating properties of the typical building materials are discussed. See *Ceram. Abs.*, **13** [4] 90 (1934). P.G.H.

PATENTS

Building block manufacture. ALBERT HENDERSON (William P. Witherow). Can. 375,237, July 19, 1938 (Dec. 17, 1936; in U. S., Oct. 21, 1936). G.M.H.

Building block and structure. C. F. SAUERBISEN. U. S. 2,124,084, July 19, 1938 (Feb. 26, 1937). A parallelepipedal brick having its bottom, one end, and one side surface provided with communicating recesses, the recesses in the side and end surfaces including an intermediate flute and the brick surface adjacent the flutes being disposed on a gradual inclination which slopes toward the flutes.

Building construction and block. J. W. PHILLIPS. U. S. 2,124,430, July 19, 1938 (March 27, 1937). A wall structure includes a plurality of superposed blocks, each block having a web on one face thereof which extends downwardly throughout the width of the block therebelow to reinforce it.

Cavity brick for building purposes. F. H. HEDINGER. U. S. 2,126,011, Aug. 9, 1938 (April 14, 1937).

Fabricated brick wall panel. EMMET V. POSTON. Can. 375,114, July 12, 1938 (May 3, 1937). G.M.H.

Lightweight ceramic article. WILLIAM R. SEIGLE (Johns-Manville Corp.). Can. 374,876, July 5, 1938 (April 8, 1937). G.M.H.

Sand facing of brick, building blocks, etc. LONDON BRICK CO., LTD., G. H. C. RACTLIFFE, AND C. W. D. ROWE. Brit. 488,278, July 20, 1938 (Nov. 3, 1936).

Tile block. HENRY JANSEN (Janline Tile Co., Inc.). U. S. 2,126,394, Aug. 9, 1938 (April 1, 1937).

Wall construction. F. H. HEDINGER. U. S. 2,126,012, Aug. 9, 1938 (Dec. 17, 1937).

Refractories

Application of physicochemical principles to the manufacture and testing of refractory products. MARCEL LÉPINGLE. *Céram., Verrerie, Email.*, **4**, 431, 433–57, 471–74 (1936); **5** [1] 13–18; [2] 45–50; [4] 135–37; [5] 172–79; [6] 212–18; [10] 325–28; [12] 409, 411–14 (1937).—Alumina and silica refractories were examined, and attempts were made to correlate the physical properties with the chemical composition. The results are tabulated. Special refractories such as chromite, silicon carbide, zirconia products, and beryllium and thorium oxides are briefly discussed. See *Ceram. Abs.*, **15** [5] 151, 156 (1936). M.V.C.

Backing up refractories with insulating material: I–II. G. E. GRIMSHAW. *Steel*, **100** [April 12] 89–94; [April 19] 51–59 (1937).—Insulation back of walls and roofs of furnaces and other metallurgical equipment is necessary to (1) save fuel, (2) produce more uniform furnace temperature, (3) allow use of thinner refractory walls, (4) reduce air infiltration, (5) increase life of the refractory, (6) reduce temperature drop in gases carried in flues and mains, and (7) reduce temperature of wall casing. In selecting the proper material, the first question is whether the insulation in back of refractories should be a block, brick, fill, or cement. The insulating brick tie in conveniently with fire brick. Cement is preferable over outside brick walls having irregular surfaces. Block have fine insulation value and are cheaper to apply. Insulation serves best when it is selected on the basis of adaptability, durability, and efficiency. H.E.S.

Basic open-hearth process: I–IV. H. I. GEIGER. *Steel*, **100** [March 29] 38–41, 80; [April 5] 39–44; [April 12] 64–68; [April 26] 48–52, 78–81 (1937).—The fundamental construction of the open hearth was conceived after it had first been applied to glassmelting. G. gives the historical background covering the development of the open-hearth furnace from the first crucible steel furnaces, using the Siemens regenerative type of firing, to the present-day open-hearth furnace. The latter furnace is commonly designed to tap heats of 90 to 120 tons. In order to increase the output, fundamental relationships in design between the various parts of the furnace have been made. The developments have largely been in port design, fuel burners, regenerators, combustion control, thermal efficiency, refractories, and general furnace construction. A description of the basic process is conveyed by presenting a log of the heating process from the charge of the scrap to the tapping of the refined steel. G. describes the various reactions that take place in the furnace and gives the steps by which these reactions are controlled. H.E.S.

Basic refractories, their use in the lining of induction furnaces. C. BOOTH AND W. J. REES. *Iron & Steel Inst. Carnegie Schol. Mem.*, **26**, 57–122 (1937); *Brit. Chem. & Phys. Abs.–B*, **57** [5] 514 (1938).—Additions of cordierite ($2MgO$, $2Al_2O_3$, $5SiO_2$) up to 25% to dead-burned magnesite lower the firing shrinkage, thermal expansion, and refractoriness under load and increase the porosity but have little effect on spalling. The ternary diagram for Al_2O_3–MgO–SiO_2 is of little value in interpreting microstructure, as equilibrium conditions are never attained. The best bonds for electrically fused magnesite are CaF_2 and $Ca_3(PO_4)_2$. Increasing the molding pressure reduces the firing shrinkage, porosity, permeability, and thermal sensitivity and considerably increases the green strength and refractoriness under load.

Chair of refractories. ANON. *Refrac. Jour.*, **13** [11] 689 (1937).—The need of a professorial chair in the universities, especially at the University of Sheffield, is emphasized. B.C.R.

Chrome ores as used in the refractories industry.

British Refractory Materials Section. *Iron & Coal Trades Rev.*, **138** [3666] 960 (1938).—The amount of fairly pure powdered magnesite required to be added to a chrome batch to convert its serpentine content into forsterite is 0.33%. Forsterite is a more refractory magnesium silicate than serpentine. This addition of magnesia, however, produced no improvement in the under-load tests at 1580°C (with 50 lb./sq. in.). Barium sulfate provides efficient bonding power at high temperatures under pressure; lime bonding is not satisfactory. M.H.

Cooling and reheating by-product coke ovens. B. M. Livezey. *Proc. Engrs. Soc. W. Pa.*, **50** [2] 27 (1937).—Due to the business decline in 1933, it became necessary to cool down 12 batteries of Koppers by-product ovens. L. gives a detailed description of the technique followed in cooling and reheating the ovens. Wall cracks and spalling were found to occur below 450°F. In returning the ovens to service, reheating was accomplished through the regenerators with uniform results. Five months after being returned to service, the ovens appear to be in as good condition as before cooling down. After the ovens had been placed in successful operation, measurements showed an expansion 1 in. greater than the contraction, possibly due to the material used for filling all the cracks that appeared on cooling. A shutdown for more than 6 to 7 months is more economical than keeping the ovens idle and hot. B.C.R.

Coöperation and research. Harold Hartley and W. J. Rees. Presented at the annual meeting of the Coke Oven Managers' Assn., London; abstracted in *Refrac. Jour.*, **13** [11] 697 (1937).—Close contact between the research worker and the man controlling the plant and processes is desirable. The coöperation between the coking and refractories industries is one of the most important means of progress in both industries. The development of the present-day coke oven from research work done at the Geophysical Laboratory, Washington, is cited as an example of what may be accomplished through proper coöperation. The advantages of standard specifications using fewer special and intricate shapes are emphasized. B.C.R.

Cupola fire brick. L. T. Makram. *Foundry Trade Jour.*, **56**, 296 (1937).—M. describes a brick designed to prevent the lowering of the melting temperature through pressure; the pressure of one brick upon another is taken up in a position where the brick should be relatively cold. The cooling of the points of contact between the brick is assured by including air spaces in the design. These brick have shown good service after twelve months in a 27-in. cupola used for melting high steel-mix charges. H.E.S.

Developments in the refractories industry. W. J. Rees. *Foundry Trade Jour.*, **56**, 56 (1937).—Composite chrome-magnesite brick are being produced and put into service. Perfection of shape through forming by powerful presses has made possible the use of very thin joints. Brick of low thermal conductivity and low heat capacity give a considerable saving in fuel. Completely mechanized plants have made production more uniform and rapid. Finished products now take 3 or 4 days instead of 2 or 3 weeks. H.E.S.

Discussion of "Refractories for iron-blast furnaces." F. Hartmann. *Stahl & Eisen*, **57**, 1079–80 (1937); see *Ceram. Abs.*, **17** [1] 21 (1938). L.R.B.

Double end-fired naphtha and gasoline re-forming furnace. Anon. *Ind. Eng. Chem.*, **30** [4] 398–99 (1938).—The refractories used in this type of furnace are described and illustrated. The walls and arches are of suspended fire tile, insulated and enclosed in removable steel panel casing. The walls and bridge walls are air cooled, and the entire furnace is supported on a heavy steel framework, entirely independent of the brick setting. F.G.H.

Effect of fluxes on cupola linings. C. K. Donoho and J. T. MacKenzie. *Bull. Amer. Ceram. Soc.*, **17** [8] 317–21 (1938). **Discussion.** C. E. Bales, L. C. Hewitt, and S. M. Phelps. *Ibid.*, p. 321.

Extraction of alumina from clay. Anon. *Bull. Imperial Inst.*, **34** [1] 79–83 (1936).—A review is given of the following processes for the extraction of alumina from materials other than bauxite, notably silicates: (1) fractional crystallization method, U.S.A.; (2) HCl acid extraction and electrothermal processes, Germany; (3) a modification of the nitric acid process, Norway; (4) Suzuki process, Japan (a development of Hall's dry process); (5) soda-lime fusion process for treating nepheline concentrates, U.S.S.R.; and (6) Blanc nitric acid process in Italy, using Italian leucite. A.P.S.

Heat transmission through walls: II. H. Sheard. *Jour. Inst. Heating Ventilating Eng.*, **5**, 388–90 (1937); *Bril. Chem. & Phys. Abs.-B*, **57** [5] 465 (1938).—The heat-transmission coefficient for a 9-in. Fletton brick wall is 0.41 B.t.u./sq. ft./hr./°F temperature difference, with or without outside rendering, and 0.42 for a 9-in. wall plastered on the inside. For an 11-in. cavity wall the coefficient is 0.30 to 0.31 with the cavity unventilated (0.32 ventilated). Further tests are in progress with forced ventilation of the cavity. An air brick 3 in. thick with 39 holes about $^3/_4$ in. square has a high pneumatic resistance.

Increased steel demand necessitates new open-hearth furnace. Anon. *Can. Machinery*, **48** [7] 21–23 (1937). D.A.B.

Insulating panel for open-hearths affords high salvage of brick. S. M. Jenkins. *Steel*, **100**, 86–88 (March 15, 1937).—Insulating panels with steel plate backing and angle iron sides are made for installation between the top of the pan and the bottom edge of the channel iron used for holding the skewback. These panels are held tightly against the silica brick by steel wedges driven through holes in the buckstays. End-wall construction includes insulated panels, three wide and two or three high, held in place by similar methods employed for side walls. Over the roof, $2^1/_2$ or $4^1/_2$ in. of insulating brick is laid dry; it is tightened up after the furnace has been brought up to working temperature. H.E.S.

Magnesite-talc rock from the Sudan as a refractory and the development of forsterite-periclase brick. Anon. *Bull. Imperial Inst.*, **34** [1] 86–89 (1936).—The introduction of lower grade material from the Anglo-Egyptian Sudan to the refractories industry is important as the available supplies of the purer types of magnesite are limited. This material yields refractory brick of good quality. The occurrence and geology of the rock as well as its chemical and mineralogical composition are described. In this instance the talc, instead of being a deleterious constituent, affords considerable benefit, for if the magnesite and talc can be made to interact and their proportions are properly adjusted, they will form a magnesium silicate (forsterite). Forsterite is a particularly valuable refractory having no inversions from room temperature to its melting point of 1910°C and a remarkable resistance to crushing under load at high temperatures. Use of forsterite as a high-temperature refractory is difficult because (*a*) the naturally occurring forsterite is always too intimately mixed with undesirable minerals to render its use possible and (*b*) the preparation of artificial forsterite from silica and magnesia has been commercially impracticable because of the high temperature required for complete reaction to take place. A mixture of natural magnesium silicates containing a higher silica content than forsterite and the requisite amount of magnesite and heated to a temperature around 1550°C is the most promising. Recognition of this fact is afforded by recent attempts in America to prepare forsterite brick by enriching a low iron-magnesian olivine with magnesia (*Jour. Amer. Ceram. Soc.*, **18** [6] 176–92 (1935)). In this case, the presence of talc and serpentine as accessory minerals in the raw material does not matter, for they are also converted to forsterite on addition of the required amount of magnesia. Tests by Tyler and Rees (*Ceram. Abs.*, **13** [8] 220 (1934)) show that mixtures within the limits of 100 parts Sudan rock to 20 parts Grecian dead-burned magnesite and 100 parts Sudan rock to 100 parts Grecian dead-burned magnesite can be considered for use in the manufacture of high-temperature refractories. The ideal method to adopt in making brick from the material

is described in detail, and the strongest briquets were those in which rims of forsterite had developed around the periclase grains. A.P.S.

Materials for construction used in Kraft paper pulp mills. ANON. *Chem. & Met. Eng.*, **45** [3] 126 (1938).—Soapstone and chrome refractories are generally used in lining smelter furnaces. B.C.R.

Olivine and forsterite refractories in America. FRED A. HARVEY AND RAYMOND E. BIRCH. *Ind. Eng. Chem.*, **30** [1] 27–32 (1938).—Forsterite, which has a melting point of 1910°C (3470°F), rarely occurs alone but is common in homogeneous combination with fayalite, $2FeO \cdot SiO_2$, as olivine. The term "olivine" covers a wide variety of compositions conforming to the orthosilicate formula, $2RO \cdot SiO_2$. Olivines with RO chiefly of magnesia and ferrous oxide are of interest as refractories; dunite deposits are located near Asheville, N. C. The crushed natural rock is treated with magnesia to convert impurities into refractory material. Enstatite ($MgO \cdot SiO_2$), talc, and serpentine are converted into forsterite in this manner; ferric oxide combines with the magnesia to form magnesioferrite, $MgO \cdot Fe_2O_3$. The properties, uses, and conditions of use of forsterite brick are given in detail. The resistance of forsterite brick to destructive agencies is being increased by (1) careful selection of olivine for use in refractories, making possible the mining of a greatly improved grade of rock; (2) elimination of the types of olivine rock containing the highest amounts of low-melting impurities, making it possible to reduce the magnesia addition and consequently to obtain an increased percentage of forsterite in the fired refractory; and (3) increasing the density of the brick by modifying the grind so as to give denser packing and by firing the brick much harder; this minimizes volume changes in service as a result of recrystallization of the olivine. Illustrated. F.G.H.

Olivine and forsterite refractories in Europe. V. M. GOLDSCHMIDT. *Ind. Eng. Chem.*, **30** [1] 32–34 (1938).—The use of forsterite as a refractory was first suggested, in 1924, by Jakob who proposed that mixtures of serpentine, quartz, and magnesium sulfate be melted in an electric furnace to obtain refractory forsterite. In 1925 Goldschmidt and Knudsen described the manufacture of forsterite products by firing talc and magnesium oxide. They found that olivine minerals would combine with magnesium oxide to form forsterite at temperatures below the melting points of any compound involved. The reactions which take place are given in detail. Forsterite refractories have proved valuable in the construction of ceramic kilns and kilns for firing magnesite refractories, in the arched roofs of copper smelting and refining furnaces, and in the hearths of forging and reheating furnaces. In the form of a ramming mass, they have been used in the lining of induction furnaces for melting nonferrous alloys and in the bottoms of electric steel furnaces. In the iron and steel industry forsterite refractories in general are not satisfactory. Their introduction into certain fields has been limited by the comparative weakness of forsterite against the action of metallurgical slags, with the remarkable exception of slags very rich in iron, and by the comparatively low resistance of forsterite brick to spalling. An improved forsterite brick is being developed, however, which shows increased resistance to slag conditions, spalling, and failure under hot load. This improvement is obtained by making the refractory from two components, a granular olivine and a ground mass which may be made from a spinel mineral, rich in magnesium and chromium, in which the olivine grains are embedded. Illustrated. F.G.H.

Rammed refractory materials. M. MUGNEROT. *Foundry Trade Jour.*, **56**, 21–23 (1937).—The prime requisites of rammed refractory materials are constancy of volume at all times during service, mechanical strength, and refractoriness. Ramming materials are employed for (1) the construction and repair of iron and steel melting furnaces and metal-working furnaces, (2) the lining of ladles, (3) stove settings, and (4) electric furnace linings. Ramming materials are silica and limestone, magnesite (tar binding) and dolomite, and fireclay silica alumina mixtures. If care is exercised in their installation, rammed linings are said to give longer life and be more economical than brick linings. H.E.S.

Refractories from the maintenance standpoint. R. L. BATELY AND E. GORDON BARBER. *Eng. & Boiler House Rev.*, **52** [1] 16 (1938).—Failure of refractories may be due to (1) faulty construction, (2) jointing, (3) expansion, (4) spalling, and (5) slagging. Each of these is discussed. B.C.R.

Spherical checker brick for hot stoves. N. KIRICHENKO. *Teoriya & Prakt. Met.*, 9 [9] 5–7 (1937); *Metals & Alloys*, 9 [5] MA282 (1938).—Much more efficient heat absorption is claimed by the use of brickwork composed of spheres, the two opposite segments of which are removed so that the flat areas produced serve as bearing surfaces. No practical trials were given to the proposed arrangement.

Stability limits of refractory materials in boiler combustion chambers. T. S. PEARSON. *Eng. & Boiler House Rev.*, **52** [1] 8 (1938).—P. discusses several points of importance in firebrick construction. In designing the arches, the inadvisability of allowing the skewbacks to rest upon the face of the brick is stressed. By setting the skewback farther back, the stresses of the arch are not transmitted to the hot face of the underlying brick. It is also important to lay the brick with thin joints, so-called brick to brick joints being the most desirable. The thickness of insulation used should be given careful consideration, so that the fire brick does not become too hot to carry the load without distortion. B.C.R.

Standardization and characteristics of blast-furnace refractories. ZYGMUND KROTKIEWSKI. *Hutnik*, **9**, 449–57 (1937); abstracted in *Chem. Zentr.*, **1938, i**, 2936.—K. urges the standardization of blast-furnace refractories, not only with regard to dimensions but also with respect to physical and chemical properties. M.V.C.

Steelmaking progress. ANON. *Steel*, **100**, 312–14, 424, 425, 445 (Jan. 4, 1937).—Forsterite brick continue to give satisfactory service in rotary kilns, copper-furnace roofs, and certain open-hearth bulkheads. Low thermal conductivity basic brick are being used for silica brick in open-hearth end walls, downtakes, and front and back walls. Basic open-hearth bottoms using magnesite exclusively have produced a bottom giving minimum porosity and minimum objectionable impurities. New type magnesite nozzles are being made by the Ritex process. For the roofs of the smaller basic electric furnaces making special alloy steels, some sillimanite refractories are now available having a density of 150 lb./cu. ft. Diaspore high alumina brick have been improved and shrinkage at high temperatures has been reduced. They are more economical than silica or clay brick where fluxing by iron oxide slags at medium temperatures is a problem. Superduty clay brick, owing to their increased spalling resistance, have displaced high-duty or first-quality clay brick in roofs of furnaces heating billets, slags, and forgings. See "Refractories meeting —," *Ceram. Abs.*, **17** [1] 22 (1938). H.E.S.

BULLETIN

Refractories for miscellaneous foundry furnaces with special reference to insulation. G. D. COBAUGH. *Amer. Refrac. Inst. Tech. Bull.*, No. 69, 8 pp. (April, 1938).—During the past ten years, there have been notable changes in foundry-furnace construction. Some of these have resulted from the effort to secure greater thermal efficiency by diminishing heat losses through furnace walls and by increasing the amount of sensible heat transfer to the charge. About as much heat is lost through furnace walls by conduction and radiation as is usually employed in heating the charge. As a result, greater demands have been imposed upon the refractory materials with which the furnaces are lined. Corresponding advances in refractories technology have led to improvements in the properties of existing types and to the development of new refractory products. The selection of refractories for specific service requirements is a problem which requires for its solution a knowledge of the furnace operating conditions and an understanding of the properties of the refractories available. H.E.S.

PATENTS

Apparatus for molding refractory crucibles. RENÉ AMAND. Fr. 820,162, Nov. 5, 1937; *Chem. Abs.*, **32**, 5595 (1938).

Construction for furnaces. H. A. MORLOCK. U. S. 2,125,193, July 26, 1938 (Dec. 24, 1937).

Furnace arch and refractory block. L. S. LONGENECKER. U. S. 2,126,901, Aug. 16, 1938 (July 16, 1936).

Lining of rotating furnaces for calcining cement or lime. CARBORUNDUM CO. Ger. 656,961, April 3, 1938 (March 27, 1935); V/80*c*. 14.01. A furnace lining is made of fireproof brick of high alumina content. The brick are cast in the usual manner and contain 80% or more alumina. D.A.B.

Manufacturing magnesium oxide and calcium carbonate. HARRY PAULING. Ger. 657,193, Feb. 10, 1938 (Jan. 18, 1935); IV*b*/12*m*. 3. MgO and $CaCO_3$ are manufactured from double compounds such as dolomite by converting the Ca into soluble saccharate by means of sugar solution and by subsequently precipitating the lime by carbonic acid (the sugar solution is used repeatedly). These reactions take place at a temperature between 20° and 30°C. D.A.B.

Patching interior surfaces of furnaces. F. W. WINKLER, F. X. MOONEY, C. R. KUZELL, AND M. T. MOUNTS (Phelps Dodge Corp.). U. S. 2,124,865, July 26, 1938 (Oct. 8, 1937). The method of patching the interior of a high-temperature continuously operating furnace comprises preparing a slurry of water and powdered refractory material, the material comprising principally silica and being proportioned chemically to produce an adhesive thermally bonded deposit at the temperatures of operation of the furnace, and pneumatically spraying a thin coating of the slurry upon an interior surface of the furnace while the furnace is being operated.

Recovery of aluminum compounds. L. FRELING AND J. DORREN. Brit. 479,293, Feb. 16, 1938 (Aug. 4, 1936).

Refractory construction for furnaces. H. A. MORLOCK. U. S. 2,125,192, July 26, 1938 (Sept. 21, 1937).

Refractory material. CARBORUNDUM CO. Ger. 658,435, March 17, 1938 (April 1, 1935); VI/80*b*. 8.17. A refractory product is produced from a fused mixture of alumina with an addition of 5 to 30% silicon dioxide. The method consists of rapid cooling after casting. The material consists of corundum crystals, a glasslike lining between crystals, and almost as much mullite. The ratio of corundum to mullite is 2 to 1. D.A.B.

Treatment of bauxite, etc. R. SCHOLDER. Fr. 821,298, April 29, 1937; *Chem.-Ztg.*, **62** [7] 75 (1938). D.A.B.

Terra Cotta

Acidproof brick joined with sulfur cement protects concrete and steel. ATLAS MINERAL PRODUCTS CO. *Steel*, **100**, 73 (Feb. 15, 1937).—Steel tanks are successfully protected by a sheathing of acidproof brick joined with sulfur base cement. In service, these tanks withstand various concentrations of hydrochloric, sulfuric, nitric, hydrofluoric, and phosphoric acids, ferric chloride, ferrous sulfate, copper sulfate, copper chloride, and zinc sulfate at temperatures up to 200°F without deterioration or leakage. H.E.S.

PATENTS

Clay-feeding mechanism adapted for use in connection with machines for making stoneware pipes, etc. H. DEAN. Brit. 488,674, July 27, 1938 (June 23, 1937).

Manufacture of ridge tile. A. M. UPTON. Brit. 488,928, July 27, 1938 (Jan. 14, 1937).

Roofing tile. A. M. UPTON. Brit. 488,868, July 27, 1938 (Jan. 14, 1937).

Solid porous bodies. FRITZ PETERSILIE. Ger. 654,949, Jan. 6, 1937; 80*b*. 9.20; *Chem. Abs.*, **32**, 3570 (1938).—Ceramic masses for lagging hot-water systems consist of a mixture of graphite, kaolin grog, and finely ground binding clay.

Whiteware

Ceramic insulators for condensers. E. ALBERS-SCHÖNBERG. *Ber. Deut. Keram. Ges.*, **15**, 199–207 (1934); *Chem. Abs.*, **32**, 1418 (1938).—The ideal insulator for condensers is air. Solid insulators which give the best results to date are those of the steatite group fired to cone 16. Recently only 80 to 90% talc has been used, the remainder being clay. An insulator composed of a eutectic with 57% talc and 42.6% clay with varying amounts of MgO was developed. Such bodies showed a much smaller dielectric loss than the regular steatite bodies.

Fine ceramic material. K. PFEFFERKORN. *Ber. Deut. Keram. Ges.*, **16**, 499–506 (1935); *Chem. Abs.*, **32**, 1417 (1938).—Tests were carried out on the substitution of selected washed kaolin for pottery clays. A mixture consisted of kaolin 46, sand 40, feldspar 8, chalk 2, and lignite 4%. It had the appearance of pottery clay; the dry resistance of the articles was satisfactory; drying was as slow as with pottery clay. The following mixture was tried for sanitary ware: kaolin 64.5, plastic clay 5.5, feldspar 26, and lignite 4%. Contraction on firing was 7%. Suitable results were obtained by using kaolin 55, chalk 6, sand 30, lignite 4, and plastic SiO_2 (240 parts water glass and 100 parts NH_4NO_3) 5%.

Heatproof china bowls in kitchen mixers. A. F. DORMEYER MFG. CO. *Steel*, **100**, 66 (March 22, 1937).—Breakage of glass bowls in the manufacture of combination kitchen mixers has been decreased about 80% by the substitution of attractive heatproof china bowls of proper size tolerances. H.E.S.

Manufacture of hygienic ceramics. J. ZEMAN. *Stavivo*, **1937**, p. 203.—The casting slip should contain a maximum of about 35 to 45% water. The mixture may be the so-called porcelain earthenware material or semiporcelain (marble in place of the feldspar). The ware is made by throwing or casting and is fired first at 1250° to 1300°C and then at 1150° to 1300°C. After being mixed, the casting slip must be allowed to season. If casting is too fast, spots are formed, *i.e.*, places richer in alkali, which fuse down completely in the fire. In cleaning, which is done in a semidry stage, there sometimes appear traces of soda which must be wiped off after the ware has been dried completely. Before glazing, the surface of the ware must be cleaned thoroughly to remove all dust, greasy spots, etc. The quality of the products depends to a large degree on accurate molds. The ware is fired in the tunnel kiln to a uniform temperature of 1250° to 1300°C, which is often difficult to achieve. R.B.

Metallizing in the pottery industry. G. W. JARMAN, JR. *Bull. Amer. Ceram. Soc.*, **17** [8] 328–29 (1938).

Tubes of hard porcelain. G. JORDAN. *Z. Ver. Deut. Ing.*, **82** [9] 275–76 (1938).—Metal tubes are replaced (in Germany) by a hard porcelain, a mixture of kaolin, quartz, and feldspar which is fired at 1400°C. The product is watertight and gastight, resistant to temperature changes, and not attacked by alkalis and acids except HF. No fatigue or change of shape was observed after aging. The principal properties are specific gravity 2.3 to 2.5, elasticity modulus 7000 to 8000 kg./mm.^{2}, hardness (Mohs) 7 to 8, tensile strength 4 to 5 kg./mm.^{2}, compressive strength 50 kg./mm.^{2}, bending strength 9 to 10 kg./mm.^{2}, impact bending strength 2 to 2.5 kg./mm.^{2}, linear heat expansion coefficient 3.5×10^{-6}, heat conductivity 0.002

cal./cm. °C sec., and softening temperature about 1500°C. The tubes are cut with diamond grinding wheels. Methods of connection and joints between porcelain and metal tubes are described. M.H.

Use of pyrophyllite as an electrical insulator. FRANK J. STEVENS. *Jour. Amer. Ceram. Soc.*, **21** [9] 330–31 (1938).

BOOK

Insulating Materials. E. H. RAYNOR. *Nat. Phys. Lab. Rept.*, **1937**. Price 2s 6d. The work on glass included measurements of the power losses in a few representative glasses of known composition, over the range of frequency from 300 cycles to 100 mc./sec. None of the large amount of published information on the electrical properties of glass covered the wide range of frequency of this investigation. Data have been accumulated on the impulse characteristics of typical porcelain insulators for systems operating at working voltages of 11 to 132 kv., and work has been carried out in which simultaneous power frequency and impulse voltages are applied to such insulators. When flashover occurs on a string of insulators during a lightning storm, damage to the insulators is largely dependent on whether the power arc follows the conduction path formed by the impulse arc. Measurements of the impulse electric strength of various dielectrics were difficult because it was not possible to obtain porcelain in sheet form. Dielectric strengths determined with cup-shaped specimens and with sheets are compared, and it is concluded that uniformity of product is more difficult to achieve in the cup or solid form than in the sheet. Comparative tests on the impulse strength of different makes of porcelain and glass have also been carried out. A.B.S.

PATENTS

Bushing structure. A. A. SKVORTZOFF (Westinghouse Electric & Mfg. Co.). U. S. 2,125,089, July 26, 1938 (Oct. 9, 1936).

Ceramic insulator. STEATIT-MAGNESIA A.-G. Fr. 822,185, Dec. 22, 1937; *Chem. Abs.*, **32**, 5595 (1938).—An insulating mass consists of 85% steatite and 2 to 10% of spinel and clay. $CaCO_3$, BaO, and ZrO_2 may also be added separately or together.

Ceramic masses for electrical insulation. C. SCHUSTERIUS. Brit. 487,961, July 13, 1938 (Jan. 30, 1936).

Fixing and securing lavatory basins and holders and supports for toilet articles to walls, etc. E. JOHNS & CO., LTD. AND E. R. CORN. Brit. 489,181, Aug. 4, 1938 (Jan. 27, 1937).

Heat or electrical conductors. MAX HAUSER. Fr. 821,318, Dec. 2, 1937; *Chem. Abs.*, **32**, 3570 (1938). In making conductors containing Si, which have high resistance to changes of temperature, the proportion of SiO_2 in the ceramic part of the crude material is maintained above that given by $1Al_2O_3:2SiO_2$, and the SiO_2 is wholly or for the greater part in a noncrystalline form. The ceramic material used may be clay as free as possible from quartz, and substances composed practically entirely of SiO_2 are added. An example contains Si 30, plastic clay 40, vitrified SiO_2 (geyserite) 20, and flux 10%.

Method and apparatus for manufacturing pottery ware. W. J. MILLER. U. S. 2,124,204, July 19, 1938 (May 29, 1936).

Equipment and Apparatus

Accurate determination of dew point. ARTHUR W. HIXSON AND G. EDWIN WHITE. *Ind. Eng. Chem., Anal. Ed.*, **10** [5] 235–40 (1938).—An apparatus which minimizes the known instrumental and observational errors in the determination of dew point is described. Illustrated. F.G.H.

Adiabatic drying. SURFACE COMBUSTION CORP. *Chem. Industries*, **39** [5] 497 (1936).—A process of drying in air is described in which the heat required for drying the product is produced by adiabatic absorption from the discharged air from the drier of the moisture given to it. The air thus dried and heated is returned for reuse. The absorbent used is a concentrated solution of lithium chloride of controlled density. A drying efficiency of 150% is found in practice. This process allows complete control of drying temperatures and humidities and is applicable at the lowest commercial drying temperature up to at least 150°F. It is applicable both to batch and continuous drying. See "Lithium—," *Ceram. Abs.*, **16** [1] 31 (1937). P.G.H.

Air drying of solids. T. K. SHERWOOD. *Trans. Amer. Inst. Chem. Engrs.*, **32**, 150–67 (1936).—Proper design and operation of drying equipment involves two basic problems: (1) the physics of moisture movement in solids and of water-vapor diffusion from solid to air stream, and (2) the engineering problems of drier design and of computations of air and heat requirements. The principal heat requirements in air drying are for (*a*) vaporization of water, (*b*) heat discarded in waste air, (*c*) heat lost from drier housing, and (*d*) heat required to heat the product, as well as trays, trucks, or conveyers, from the inlet to the outlet temperature. The principal items under the control of the designer are heat lost in the waste air and heat lost by convection and radiation to the surroundings. The latter is a matter of proper structural design and adequate insulation. In regard to the former, there is a common misconception that the sensible heat loss increases with the exhaust air temperature. The water-vapor carrying capacity of air increases so rapidly with temperature, however, that the decrease in amount of air required more than offsets the increase in temperature, and the sensible heat loss at 80°C is ordinarily considerably less than at 40°C for the same relative humidity of the waste air. For any fixed waste-air temperature, the air requirement and hence the sensible heat loss will be a minimum at the highest waste-air humidities. Too-high humidities, however, reduce the rate of drying and the capacity. As a practical compromise, the waste-air humidity should be maintained at about 60%. See *Ceram. Abs.*, **16** [2] 68 (1937). H.E.S.

Air filter. ANON. *Mill & Factory*, **21** [6] 107 (1937).—A cleanable metal-fabricated air filter for air conditioning plants, blowers, and compressors is described. It is said to have a cleaning efficiency of 99%. D.A.B.

Airless shot-blasting. WHITTAKER ET AL. *Foundry Trade Jour.*, **56**, 13–14 (1937).—No. 16 to No. 24 abrasive shot gave good results and showed minimum ware of blades. The best pressure results were obtained with 40 to 60 lb./sq. in. This method of cleaning is believed to be superior to sandblasting. H.E.S.

Apparatus for determining particle size. WILLIAM W. NIVEN, JR. *Eng. News-Record*, **120** [4] 515 (1938).—Apparatus and a method of determining particle-size distribution are described. B.C.R.

Applications of electric furnaces and controlled atmospheres. H. C. BOSTWICK. *Ind. Heating*, **5** [7] 587–92, 636 (1938).—B. gives the metallurgical reasons for applying controlled atmospheres in bright annealing and the prevention of decarburization and for obtaining reducing qualities. Gases and gas mixtures used and installations are described. M.H.

Approximate specific-gravity determination. JOHN G. WAUGH. *Ind. Eng. Chem., Anal. Ed.*, **10** [4] 209–11 (1938).—Apparatus has been developed for rapid determination of the approximate specific gravity of small objects of restricted ranges of weight and density. While restricted to a given range, the instrument may be adapted to various specific gravity ranges. Illustrated. F.G.H.

Ball, rod, and tube mills. WILLIAM H. WITHINGTON. *Ind. Eng. Chem.*, **30** [8] 897–904 (1938).—The operating characteristics of ball, rod, and tube mills of all types are presented in detail. The application of the various types of mills to wet or dry grinding and to open-circuit or

closed-circuit grinding is also thoroughly discussed. A data sheet lists the grinding equipment used and the operating characteristics involved in the grinding of twelve raw materials for seventeen different purposes. Illustrated. F.G.H.

Carbon-molybdenum steel pipe for service at 750° to 1000°F. ANON. *Combustion*, **9** [6] 35–36 (1937).—New specifications for seamless alloy-steel pipe for temperatures of 750° to 1100°F include (1) heat treatment, (2) chemical composition, (3) tensile strength, (4) hydrostatic test, (5) flattening and bending, and (6) variation in weight and dimensions. Supplementary requirements of an optional nature for central station service are given, covering check analysis, transverse tension tests, flattening tests, finish, metal structure, etching, and rejection. H.E.S.

Clay washer. H. W. DIETERT CO. *Foundry Trade Jour.*, **56**, 296 (1937).—A new clay washer automatically washes the clay substance from molding sands. Hand siphoning and considerable labor are eliminated, and the time for washing is reduced. Illustrated. H.E.S.

Drying ceramic products. H. KRAUSE. *Keram. Rundschau*, **45** [36] 412–13 (1937).—K. outlines scientific ideas. He distinguishes between pore and adherence water and combined water. The shrinkage process is discussed. Volatilization, migration of moisture, coagulation of colloids, and heating affect the velocity of drying. Drying processes (pulverization, alternate current, forced ventilation) are theoretically dealt with. Drying in hot moist air is advocated. F.E.V.

Dust-measuring device. ANON. *Eng. News-Record*, **120** [1] 24 (1938). B.C.R.

Easily constructed orifice. CHESTER P. BAKER AND WILLIAM A. MCGRATH. *Ind. Eng. Chem., Anal. Ed.*, **10** [7] 402 (1938).—An orifice for the measurement of fluid pressure or velocity in a pipe line is constructed from ordinary pipe fittings. Illustrated. F.G.H.

Electrostatic solid separations. HENRY M. SUTTON AND G. W. JARMAN, JR. *Chem. & Met. Eng.*, **45** [5] 277 (1938).—Success in electrostatic separations depends upon the existence of differences in electrical conductivity of the particles, regardless of their iron content or magnetic properties. A new type of electrostatic separator that gives cleaner separations with a fewer number of passes is described. A method which does not require electricity is known as pyroelectric separation; it consists in heating and cooling a mixture of particles and allowing it to pass down a chute made of a material which causes particles of opposite polarity to cling longer than those having similar polarity to that of the chute. Mica may be separated from sand in this manner. B.C.R.

Ferrous alloys obtained by use of boride crystals. M. C. SMITH. *Steel*, **100**, 46–47 (March 29, 1937).—A crystalline mixture of metallic boride added to low-carbon steel or common cast iron in various proportions or alloyed with nickel as a carrier produces useful and unique alloys. H.E.S.

Filtration. Accuracy of prediction of plant operation from test data. E. L. MCMILLEN AND H. A. WEBBER. *Ind. Eng. Chem.*, **30** [6] 708–16 (1938).—Small-scale, constant-pressure, test filtration data are converted into constants representing filter cake and cloth resistances by utilizing the new filtration equations of Ruth (*Ceram. Abs.*, **15** [6] 186 (1936); **16** [3] 95 (1937)) and used to predict capacities of a variety of larger filters under various conditions of temperature, sludge concentration, and pressure (or vacuum) of filtration. Ruth's equations are entirely reliable. Illustrated. F.G.H.

Gloss meter. EBEN E. JELPKE. *Jour. Sci. Instruments*, **15** [5] 181 (1938).—The gloss meter is intended for comparative measure of the gloss or dullness of paint, varnish, lacquer, enamel, etc. The reflection and dispersion of a collimated beam of light are measured from the surface under test. The device consists of a lamp unit with a condenser and diaphragms, a base casing arranged for accurate location of test samples, a galvanometer, and a photocell tube with a special photocell. A test plate representing 100% gloss is supplied. The galvanometer is calibrated in percentage of gloss, ranging from 0 to 100%. The price, including a lamp transformer, is £39. Illustrated. J.L.G.

Grinding fundamentals. WALTER L. MAXSON. *Chem. & Met. Eng.*, **45** [5] 226 (1938).—Methods of disintegration are affected by numerous factors including constitution and size of the feed, character of the surfaces, velocity of impact, mill speed, type of liner, weight of charge, size of grinding media, rate of flow, and type of circuit. Any strains or stresses existing in the material often render subsequent grinding much easier, *e.g.*, rapidly cooled cement clinker is easier to grind than that which has been cooled slowly. The coefficient of friction of the feed is also important. In general, materials that are extremely hard to break require higher impact velocities than softer materials. The operating speed of the mill and the weights of the feed and ball charges are closely related when using cylindrical grinding mills. The same results may be secured by operating with either a low ball charge at high speed or a high ball charge at low speed. Wet grinding is usually preferable because of the elimination of dust and the more efficient use of power. In dry grinding, consideration must be given to the coating of the balls or liners, which in some cases resist all efforts made to form such a coating. B.C.R.

Help prevent silicosis. ANON. *Mill & Factory*, **21** [2] 112–13 (1937).—Blower and dust-suction hoses are recommended for abrasives, and blower hoses for fumes. These hoses are of the suction or light-pressure type and withstand the action of abrasives. D.A.B.

High-vacuum gas-analysis apparatus. EDWARD C. WARD. *Ind. Eng. Chem., Anal. Ed.*, **10** [3] 169–71 (1938).—Individual components are determined within 0.02 to 0.1%, depending on their concentration in the original sample. Results obtained by this method have been used for equipment design and plant control for several years. Illustrated. F.G.H.

Improved trap for moisture determination by distillation. EARLE E. LANGELAND AND RICHARD W. PRATT. *Ind. Eng. Chem., Anal. Ed.*, **10** [7] 400–402 (1938).—A trap is described which is suitable for use in determining moisture by distillation with immiscible liquids heavier than water. Its operation is independent of thermal environment, and it requires no adjustment of reflux rate. The use of a surface-tension depressant facilitates the correct reading of the water volume. Illustrated. F.G.H.

Jet pulverizing. MARCEL A. LISSMAN. *Chem. & Met. Eng.*, **45** [5] 238 (1938).—L. describes the operation of a jet pulverizer, called the Micronizer, for use in dry grinding in the subsieve range (625- to 2500-mesh). B.C.R.

Low-alloy steel for high-temperature service. C. L. CLARK AND R. S. BROWN. *Combustion*, **9** [4] 33–34 (1937).—The high-temperature characteristics of a carbon-molybdenum steel are described. H.E.S.

Mechanical concentration methods. BYRON M. BIRD. *Chem. & Met. Eng.*, **45** [5] 264 (1938).—B. reviews concentration methods, including both the wet and dry processes. Reference is made to the purification of glass sands. B.C.R.

Metal spraying and its aid to the oil industry. R. E. KRENKLER. *Welding Jour.* [N. Y.], **17** [5] 20–21 (1938).—Spraying of stainlesss steel on the surface of hot oil pump plungers increases life owing to increased wear and corrosion resistance. When worn, they may easily be built up again with sprayed metal. The advantages of spraying over welding for the purpose are that there is no danger of warping or localizing heat stresses, there is greater uniformity in size over the built-up area thus requiring less excess metal to be machined off, etc. W.H.B.

Microrefractometer of simple design. A. E. EDWARDS AND C. E. OTTO. *Ind. Eng. Chem., Anal. Ed.*, **10** [4] 225–26 (1938).—The laboratory construction of a simple microrefractometer is described and illustrated. F.G.H.

Mixers in the process industries. GORDON MACLEAN AND EMERSON J. LYONS. *Ind. Eng. Chem.*, **30** [5] 489–92 (1938).—The mixer which will give the best results depends on translation factors, the investigation of which is of great importance. Illustrated. F.G.H.

Moisture determination. CHARLES W. GRIFFITHS. *Ind. Eng. Chem., Anal. Ed.*, **10** [7] 394 (1938).—G. describes a supplementary apparatus which has proved to be of value where the Dean-Stark method of moisture determination has been adapted to high moisture containing materials. Illustrated. F.G.H.

Multimotor drives. R. F. EMERSON. *Factory Management & Maintenance*, **96** [6] 88–90 (1938).—E. considers the problems of running conveyers in sequence and of operating two or more motors on one drive. Illustrated. J.L.G.

Multiple use of pebble and ball mills. E. M. UNDERWOOD. *Ind. Eng. Chem.*, **30** [8] 905–908 (1938).—The adaptation of various types of ball and pebble mills to specialized grinding jobs involving variable conditions of pressure or vacuum, evaporation, and heat exchange is described and illustrated. F.G.H.

Particle measurement problems. LINCOLN T. WORK. *Chem. & Met. Eng.*, **45** [5] 247 (1938).—(*1*) *Sieve-method:* Separation of materials into graded fractions of approximately 50 microns in size and coarser may be accomplished by the use of sieves. Errors may arise from nonuniformity of the sieve cloth, which becomes less uniform with use. This problem may be partially solved by using perforated plates of finer sizes than have heretofore been used. There is considerable room for improvement in agitating procedures and machines. (*2*) *Elutriation method:* The variation of the settling velocity of particles in a fluid, either a liquid or a gas, with particle diameter is a basis of separation used extensively in the range of 5 to 100 microns. Operating difficulties make it desirable to check the method against inadequate separations and against abrasion of material by suitable control methods. (*3*) *Sedimentation method:* If a suspension of particles in a liquid is shaken up until it is uniform and the individual particles are sufficiently free to settle, the changes in density or opacity or the weight of material passing a given plane in the chamber may be used to determine the distribution of particle size. One of the limiting features is the fact that dilution of particles insures freedom of settling but at the same time lowers the sensitivity of the observation which is to be made. (*4*) *Microscopic method:* Because of the optical fringes which appear on the particle images, it is dangerous to rely upon microscopic measurement in the range 0.2 to 0.3 micron. The use of ultra-violet light permits microscopic measurement of still smaller sizes with reasonable accuracy. (*5*) *Miscellaneous methods:* The turbidimeter method may be used in the range 0.2 to 50 microns. Red and green light were found to give different results for turbidity. Methods relying on the sorption of dye or vapors upon solid surfaces offer possibilities of measuring surfaces but are subject to selective differences. See *Bull. Amer. Ceram. Soc.*, **17** [1] 1–5 (1938). B.C.R.

Particle size analyzer. ANON. *Mill & Factory*, **21** [3] 174, 176 (1937).—An analyzer for determining particle sizes of fine dry powdered materials such as cement, gypsum, and china clay is described. A series of fractions may be obtained, 0- to 5- or 0- to 3-micron separations giving a rapid check. D.A.B.

Performance of mixing equipment. R. C. GUNNESS AND J. G. BAKER. *Ind. Eng. Chem.*, **30** [5] 497–500 (1938).—The lack of suitable standards and test methods, either direct or arbitrary, for use in evaluating and judging performance has impeded the perfecting of mixing and agitating equipment. The authors present the development of general methods for testing and evaluating mixing equipment and indicate the application of the results to the operation of the equipment in the most efficient manner and to the selection of the proper agitator for a given mixing problem. F.G.H.

Portable photoelectric daylight factor meter. H. TINSLEY AND CO. *Jour. Sci. Instruments*, **15** [4] 140–41 (1938).—Weight 28 pounds. Price, exclusive of calibration at the National Physical Laboratory (England) which is obligatory, is £31 10s. Illustrated. J.L.G.

Precise method for sieving analysis. M. WEBER, JR., AND RAYMOND F. MORAN. *Ind. Eng. Chem., Anal. Ed.*, **10** [4] 180–84 (1938).—Illustrated. F.G.H.

Propeller-type mixers. E. S. BISSEL. *Ind. Eng. Chem.*, **30** [5] 493–96 (1938).—B. discusses the theory of propeller-type mixing and the factors involved in the selection of suitable mixers. Illustrated. F.G.H.

Pulverizers with air separation and air drying. W. A. KOREN. *Ind. Eng. Chem.*, **30** [8] 909–15 (1938).—K. discusses the principles of fine grinding softer materials with a hardness less than four to five. The types of mills used for fine grinding are briefly reviewed, and the types of equipment used for air separation of the ground material are described in detail. The development of mill drying, whereby heat in the form of high-temperature gases is introduced to a mill while it is pulverizing material containing moisture, is also discussed. Illustrated. F.G.H.

Pyrometer. ANON. *Mill & Factory*, **21** [5] 150 (1937).—A pyrometer capable of measuring the temperature of iron or iron alloys in the open or flame-heated hearth furnace is described. The pyrometer can be obtained to cover two ranges, 900° to 1900° or 1700° to 3500°F. D.A.B.

Road haulage for brickmakers: II–III. RICHARD TWELVETREES. *Brit. Clayworker*, **47** [553] 53–55; [554] 91–95 (1938).—Investigations on truck performance and capacities are described. For Part I see *Ceram. Abs.*, **17** [7] 258 (1938). R.A.H.

Separation by magnetic methods. SAMUEL GIBSON FRANTZ. *Chem. & Met Eng.*, **45** [5] 274 (1938).—The principles and equipment used in magnetic separations are reviewed. B.C.R.

Simple method for preparing glass electrodes. M. L. NICHOLS AND JOHN M. SCHEMPF. *Ind. Eng. Chem., Anal. Ed.*, **10** [5] 286 (1938).—A simple procedure for making a sensitive durable glass electrode is given. Accurate measurements may be made with this electrode using a portable galvanometer with a sensitivity of 40 megohms and an ordinary galvanometer. Illustrated. F.G.H.

Simplified precision oil manometer. T. C. CHADWICK AND S. PALKIN. *Ind. Eng. Chem., Anal. Ed.*, **10** [7] 399–400 (1938).—Illustrated. F.G.H.

Simplified quinhydrone electrode. Application in determining the p_H of liquids and semiplastic solids. GEORGE P. SANDERS. *Ind. Eng. Chem., Anal. Ed.*, **10** [5] 274–75 (1938).—Illustrated. F.G.H.

Steel casting design for the engineer and foundryman. C. W. BRIGGS, R. A. GEZELIUS, AND A. R. DONALDSON. *Jour. Amer. Soc. Naval Engrs.*, **50** [5] 174–211 (1938).—Design considerations to prevent shrinkage cavities are discussed at length with the aid of charts for typical sections which illustrate the effect of section, mass, contour, etc., on the extent and position of the cavity. The charts also show the effect of coring and position and size of internal and external chills on the cavities produced. They are drawn to the scale of the original cast section with cavities, chills, cores, etc., in proportion, thus giving a quantitative aspect to the problem of eliminating defects by the means illustrated. W.H.B.

Technical auxiliary devices for X-ray and gamma ray irradiation. O. VAUPEL. *Berg- & Hüttenmänn. Monatsh. Montan. Hochschule Leoben*, **86** [6] 121–24 (1938).—Apparatus and testing methods for the determination of fine structure by X-rays are discussed. F. STÄBLEIN. *Ibid.*, pp. 124–28.—S. describes the effectiveness and limits of X-ray and gamma ray irradiation of steel. R. BERTHOLD. *Ibid.*, pp. 128–29.—Apparatus, equipment, and measuring and testing methods are discussed. M.H.

Trapping water and dust from compressed air. ANON. *Mill & Factory*, **21** [3] 98, 205 (1937).—Dust and water are removed from compressed air by causing the air to enter a cylinder whose volume is somewhat large. D.A.B.

Wetting characteristics of solids and liquids. CHARLES A. MURRAY AND F. E. BARTELL. *Amer. Paint Jour.*, **22**, 7–9, 60, 62–68 (Nov. 15, 1937); *Chem. Abs.*, **32**, 265 (1938).—Measurements proposed to indicate degree of wetting and certain scales for comparing wetting characteristics are as follows: (1) the degree of wetting of a solid by a liquid may be evaluated by the determination of the

adhesion-tension value of the system; (2) a scale upon which solids may be placed according to their wetting characteristics is known as the K_{N3} scale and is a yardstick by which the wetting characteristics of a solid may be measured; (3) a scale also exists upon which pure liquids may be placed according to their wetting characteristics, a scale of the interfacial tensions of liquids against water, known as the S_{N3} scale and serving as a yardstick to measure the wetting characteristics of liquids. Charts show the position of several solids and liquids on the K_{N3} and the S_{N3} scales, the relation of adhesion tension of K_{N3} and S_{N3} scales, and the effect of moisture in the silex-organic systems. The degree to which a solid is wetted by a liquid can be evaluated by means of the adhesion-tension value, but the prediction of the degree of wetting requires a knowledge of the wetting characteristics of both the solid and the liquid, each factor playing an equally important part in determining the magnitude of the adhesion tension. Anomalies in the wetting characteristics of liquid mixtures may be explained as being due to the preferential adsorption by the pigment of one constituent of the mixture, thereby altering the effective surface properties of the solid and the concentration of the solution.

Windsor plants install equipment to eliminate harmful dust. ANON. *Can. Machinery*, **48** [12] 176–78 (1937).—Two Windsor manufacturing concerns have installed a special dust arrester and a cyclone exhaust fan to eliminate dust due to tumbling, grinding, mixing, sandblasting, and milling. D.A.B.

BULLETIN

Mineral thermometer. OLIVER R. GRAWE. *School Mines & Met., Univ. Missouri, Tech. Series Bull.*, **12** [4] 8 pp. (1937).—G. compiles 180 minerals, giving their melting points and transition temperatures in the form of a thermometer. Temperatures are also given in the pyrometric cone scale. P.G.H.

PATENTS

Apparatus for determining the opacity of paper and other materials. OTTO MAASS AND R. E. RICHARDSON (Canadian Pulp and Paper Research Corp.). U. S. 2,125,639, Aug. 2, 1938 (Oct. 16, 1935).

Apparatus for projection of molten pulverized bodies. F. P. C. BENOIT. U. S. 2,125,764, Aug. 2, 1938 (Oct. 19, 1935).

Classification of solids in suspension. W. W. TRIGGS (Dorr Co., Inc.). Brit. 488,745, July 27, 1938 (May 13, 1937).

Dust-laden air-treating apparatus. F. S. W. DOBBS AND JAMES ANDERTON (Mavor & Coulson, Ltd.). Can. 375,202, July 19, 1938 (Aug. 2, 1937). G.M.H.

Extraction of dust from air and gases by spraying with liquids. T. G. NYBORG AND MINING ENGINEERING CO., LTD. Brit. 487,672, July 6, 1938 (Nov. 21, 1936).

Filter presses. MANOR ENGINEERING CO., LTD., AND E. W. MALKIN. Brit. 488,280, July 20, 1938 (Nov. 30, 1937).

Fusing borates. F. A. BEIK (Pacific Coast Borax Co.). U. S. 2,124,101, July 19, 1938 (March 25, 1937).

Gas analyzing apparatus. ALAN P. SULLIVAN (Power Patents Co). Can. 374,753, June 28, 1938 (June 28, 1937). G.M.H.

Instruments for determining the roughness of surfaces. H. SHAW. Brit. 487,710, July 6, 1938 (March 25, 1937).

Means for de-airing clay in extrusion presses. WIENERBERGER ZIEGELFABRIKS- UND BAUGES AND ERNST KRIEGE. Austrian 153,048, April 11, 1938; *80b.; Chem. Abs.*, **32**, 5595 (1938).

Method and apparatus for mixing finely divided material. PAUL GOEBELS. U. S. 2,125,913, Aug. 9, 1938 (March 4, 1936).

Photoelectric gloss meter. L. A. CARPENTER AND E. J. SCHREINER (Oxford Paper Co.). U. S. 2,127,477, Aug. 16, 1938 (Dec. 16, 1935).

Quartz mill. F. L. MINNICK (Mephisto Quartz Mill Co.). U. S. 2,126,406, Aug. 9, 1938 (May 22, 1936).

Rotary furnace, kiln, or drier. FREDERIC LLOYD AND HERMAN LINDARS. Can. 374,946, July 5, 1938 (March 23, 1936). G.M.H.

Sample splitter. J. B. PARSONS (W. S. Tyler Co. of Canada, Ltd.). Can. 374,911, July 5, 1938 (Oct. 30, 1936). G.M.H.

Spray head. A. C. ARBOGAST (Northern Indiana Brass Co.). U. S. 2,125,863, Aug. 9, 1938 (Oct. 26, 1936).

Supporting means for gyratory sifters. E. G. BERRY AND C. L. REIMULLER (B. F. Gump Co.). U. S. 2,123,876, July 19, 1938 (March 12, 1936).

Vibratory screen. W. H. POPP AND E. A. EBERT. U. S. 2,126,031, Aug. 9, 1938 (May 28, 1936).

Kilns, Furnaces, Fuels, and Combustion

Automatically controlled heating furnace increases metallic yield 1%. M. J. CONWAY. *Steel*, **100**, 38–40, 66 (March 22, 1937).—The automatic control of furnace pressure, temperature, and atmosphere, all keyed into one control board, has shown marked improvement in the performance of batch-type heating furnaces. Effective economies in fuel and mill yield have been obtained by better treatment during the heating process. H.E.S.

By-product coke capacity shows increase. ANON. *Steel*, **100**, 48–49 (Jan. 11, 1937). H.E.S.

Colloidal fuel. D. BROWNLIE. *Chaleur & Ind.*, No. 214, pp. 203–207 (1938).—The history of the development of colloidal fuel from its invention by Plausson in 1879 to the Cunard process of 1937 is given. There is little information on its behavior in practice. See *Ceram. Abs.*, **14** [9] 228 (1935). V.D.F.

Design and firing of kilns: V. ANON. *Brit. Clayworker*, **47** [554] 68–70 (1938).—The relative advantages of round and rectangular kilns are discussed, and the Richardson suspended arch kiln, the modern Hoffman kiln, and a modern French Hoffman kiln are described. For Part IV see *Ceram. Abs.*, **17** [8] 287 (1938). R.A.H.

Determination of carbon and hydrogen. A compact, movable, and easily built combustion train. SAMUEL NATELSON AND EDWIN B. CONNOR. *Ind. Eng. Chem., Anal. Ed.*, **10** [5] 276–79 (1938).—Illustrated. F.G.H.

Determination of forms of sulfur in insoluble residues from hydrogenated coal. R. F. ABERNETHY, H. M. COOPER, AND E. C. TARPLEY. *Ind. Eng. Chem., Anal. Ed.*, **10** [7] 389–90 (1938).—A procedure is described for determining not only the sulfur content but also the forms of sulfur and its distribution in insoluble residues obtained from the hydrogenation of coal. F.G.H.

Gas-liquid equilibria for the system methane–butane. G. W. NEDERBRAGT. *Ind. Eng. Chem.*, **30** [5] 587–88 (1938).—Equilibrium constants for methane and *n*-butane at three temperatures and at three pressures are reported. Illustrated. F.G.H.

Heat transmission by radiation. E. F. M. VAN DER HELD. *Gesundh.-Ing.*, **60**, 201–202 (1937); *Brit. Chem. & Phys. Abs.–B*, **57** [5] 465 (1938).—An equation is developed which takes into account the first reflected and the direct radiation. It is claimed to be more generally applicable than Christiansen's formula.

Manufacturing industrial gases by means of electricity. A. T. STUART. *Can. Machinery*, **48** [8] 21–23 (1937).—Coal to gas at low cost is achieved by the Hydro Electric Power Commission of Ontario, Canada. Complete gasification of coal by means of oxygen obtained by the electrolysis of water results in a gas better than ordinary producer gas or gas obtained by water-gas sets common to gas industries. All operations are performed on a commercial scale with standard equipment; 2000 cu. ft of oxygen and 4000 cu. ft. of hydrogen are produced per hour. Fifteen tests running from 6 to 15 hr. produced gas at the rate of 250,000 cu. ft./day. The cost of 450 B.t.u. of gas was determined at 27¢ or 6¢ per therm. Sale of the hydrogen would bring the cost down to almost nothing. This is a source of fuel for the steel, ceramic, and metallurgical industries. D.A.B.

New laboratories of the Bureau of Mines Petroleum Experiment Station. HAROLD M. SMITH. *Ind. Eng. Chem., Anal. Ed.*, **10** [5] 287–92 (1938).—The construction and equipment of the new experiment station at Bartlesville, Okla., which is devoted to the study of problems confronting the petroleum and natural gas industry, are described and illustrated. F.G.H.

Phase equilibrium in hydrocarbon systems: XXI, Thermodynamic properties of isobutane. B. H. SAGE AND W. N. LACEY. *Ind. Eng. Chem.*, **30** [6] 673–81 (1938).—Specific volumes, vapor pressures, heat capacities, Joule-Thomson coefficients, and latent heats of vaporization were experimentally determined at temperatures from 70° to 250°F. From these data, together with other pertinent published information, the changes in enthalpy, entropy, and fugacity for changes in temperature and pressure were calculated. The results of the experimental work and values of the derived properties are given in tables and graphs. For Parts **XIX–XX** see *Ceram. Abs.*, **17** [5] 195 (1938). F.G.H.

Phenomena within the plastic range of coals. J. SANJANA. *Trans. Mining, Geol., & Met. Inst. India*, **34** [1] 56–64 (1938).—Different coals behave differently when subjected to the same conditions of heating. Tests have confirmed S.'s observation that some coals have exothermic reactions, others endothermic, during the plastic range. This fact accounts for the different heat consumptions during coking in gasworks and coke ovens where different mixtures of coals are used. Even two good coking coals when mixed together yield an inferior quality of coke, and two bad coking coals when mixed give a very good coke. The heat evolution or absorption does not follow the rule of proportionality when coals are mixed together. S. concludes that the phenomena during the plastic range of bituminous coals consist of softening of the coal, melting of the bitumen, evolution of the gas, sometimes swelling of the coal, and the evolution or absorption of heat during the plastic range, according to whether the physical and chemical reactions are exothermic or endothermic. He emphasizes the importance of laboratory work to practical operations, corrects the erroneous idea of the evil effects of moisture in coal on the heat consumption during the coking process, and points out that all coals are not alike as far as the heat consumption during carbonization is concerned. A.P.S.

Relation between volatile matter and hydrogen-carbon ratio of coal and its banded constituents. C. H. FISHER. *Ind. Eng. Chem., Anal. Ed.*, **10** [7] 374–78 (1938).—Using data from the literature and giving special attention to the petrography, F. studied the relation between volatile matter and the hydrogen-carbon ratio. Plotting these two values against each other gave two curves, approximated by three straight lines. Anthraxylons (vitrain and clarain) are found in one curve, whereas the other constituents (fusains, attrital matter, durains, and spores) occur on the other. The equations representing these straight lines can be used to relate the volatile matter and hydrogen-carbon ratios of the constituents with moderate accuracy. A more interesting and useful relationship is that between the volatile matter and the square of one hundred times the hydrogen-carbon ratio. Two straight lines result when these are plotted. Vitrains and clarains fall on the shorter line, and the other constituents fall on the longer line. Equations defining these lines apply with fair accuracy to anthraxylons of all ranks and to other constituents from low-volatile fusains to high-volatile spores. Probably most important is the determination of the approximate petrographic composition of coals from proximate and ultimate analyses, but the equations should be useful also in ascertaining the quality of isolated constituents and in correlating chemical reactions of coal with rank and petrography. By plotting volatile matter against the sum of the hydrogen and carbon contents and using these equations, a satisfactory estimate of the petrography can be made in many instances from the proximate and ultimate analyses. Illustrated. F.G.H.

Small kiln for grinding disks. W. HANUSCH. *Schleif- & Poliertech.*, **15** [1] 3–4 (1938).—A kiln of 2 cu. m. sagger space requires short firing and cooling, the entire operation taking 16 days. F.E.V.

Tunnel kilns in the heavy clay industry. G. C. MATTHEWS. *Brit. Clayworker*, **47** [554] 83–87 (1938).—M. gives a short history on the development of kilns, the advantages and disadvantages of car tunnel kilns, and a description of tunnel kilns for building brick. R.A.H.

BULLETINS

Dewatering and drying of coal. JAMES R. CUDWORTH AND ELLIS D. HERTZOG. *U. S. Bur. Mines Information Circ.*, No. 7009, 31 pp. Free. Information is given on the dewatering and drying of coal, the needs for this process in various fields, available equipment, and current American practice. R.A.H.

Fuel Efficiency in Cement Manufacture, 1909–1935. NICHOLAS YAWORSKI, VIVIAN SPENCER, GEOFFREY SAEGER, AND O. E. KIESSLING. Report of National Research Project of the Works Progress Administration in coöperation with the U. S. Bureau of Mines, 1938. A survey is made of a typical fuel-consuming industry. The average consumption of energy at American cement plants declined from 189 lb. of coal or coal equivalent per barrel of cement in 1914 to 159 lb. in 1935. Continued progress of fuel efficiency in cement manufacture is expected as new improvements are adopted and as equipment already successfully applied is more extensively introduced.

Since progress of fuel economy in the cement industry has been less than in more important fuel-consuming industries, notably electric power stations and steam locomotives, the data for this are presented as a conservative picture of technological advances made in fuel utilization.

Fuel-consuming industries have achieved substantial savings by the recovery and use of by-product fuels formerly wasted, such as coke-oven, blast-furnace, or refinery gases. Other savings have been effected by (1) the use of devices for retrieving the heat formerly lost in stack gases or hot products and using it for preheating raw materials and air for combustion or for generating steam; (2) reductions in heat and power requirements through adoption of speedier and more continuous methods of manufacture as in steel plants and petroleum refineries; (3) the prevention of heat losses through radiation, convection, or conduction with the use of insulation, seals against cold-air leakage, and other devices; (4) improved techniques for more efficient transfer of heat and power; (5) more efficient generation of power through the use of steam turbines, high steam pressures, and superheat and waste-heat boilers; and (6) the improvement of operating conditions with the greater use of control instruments and with more skilful operators.

Smoke abatement. Compiled by J. F. BARKLEY. *U. S. Bur. Mines Information Circ.*, No. 7016, 19 pp. Free.—Selections from papers by O. P. Hood and four articles by him are presented. R.A.H.

PATENTS

Apparatus for firing ceramic material. PAUL GATZKE. U. S. 2,126,881, Aug. 16, 1938 (Dec. 9, 1935). The combination of a tunnel furnace, means for indirectly heating the tunnel furnace to substantially the desired temperature, a firing truck traversable through the tunnel furnace, and means transportable through the tunnel furnace on the firing truck to introduce reducing gas into the interior of a charge of ceramic ware upon the firing truck.

Electric furnace. P. B. CROCKER (Sentry Co.). U. S. 2,126,454, Aug. 9, 1938 (Nov. 5, 1935).

Electric heating elements. BRITISH THOMSON-HOUSTON CO., LTD., P. B. BRUNT, AND C. E. DAVIS. Brit. 488,370, July 20, 1938 (Jan. 5, 1937).

Manufacture of a solid stable fuel. A. RAU, A. SOMMER, AND H. BAUR. Swiss 193,018, Aug. 11, 1936; *Chem.-Ztg.*, **62** [7] 75 (1938). D.A.B.

Process for the production of core electrodes. FRANZ LEITNER. U. S. 2,124,255, July 19, 1938 (May 22, 1935). A process for the production of core electrodes comprises placing a pipe in a mold containing liquid steel and then

filling the pipe with a refractory material having a melting point above 900°C.

Temperature-responsive devices. W. J. G. COSGRAVE AND ELECTRIC RESISTANCE FURNACE CO., LTD. Brit. 489,005, July 27, 1938 (Jan. 16, 1937).

Treatment of flue gases. SOC. ANON. D'ÉTUDES DES BREVETS ET PROCÉDÉS COANDA, SOC. COANDA. Fr. 821,-397, May 3, 1937; *Chem.-Ztg.*, **62** [6] 66 (1938). D.A.B.

Tunnel kiln for firing ceramic ware. GENERAL MOTORS CORP. Brit. 488,262, July 13, 1938 (Jan. 4, 1936).

Geology

Anorthite from Duke Island, Alaska. J. J. GLASS. Presented at meeting of Mineralogical Society of America, Dec., 1935; abstracted in *Amer. Mineralogist*, **21**, 201 (1936).—During a study of the rocks of Duke Island, Alaska, a plagioclase feldspar unusually high in calcium was recognized. Chemical analysis, confirmed by optical properties, shows this feldspar to be an unusually pure anorthite. The massive feldspar, pearl gray on a freshly broken surface, weathers white and forms bands or vein-like masses intergrown with glossy black crystals of hornblende 2 ft. long. The rock in which the plagioclase occurs is a coarse-grained hornblende pegmatite, striking in appearance. Plagioclase feldspars high in anorthite molecules are rarely found in nature. Those to which the Alaskan anorthite are comparable occur as crystals in volcanic bombs. F.J.Z.

Bentonite. C. V. *Verre & Silicates Ind.*, **9** [8] 93–94 (1938).—The characteristics and properties of bentonite and its principal industrial applications are described. See *Ceram. Abs.*, **17** [5] 196; [6] 229 (1938). M.V.C.

Bleaching clay: VIII, Adsorption process in the vapor phase. R. FUSSTEIG. *Petroleum Engr.*, **9** [7] 99–102 (1938).—Clay materials act to purify petroleum products by polymerizing unstable hydrocarbons to higher boiling compounds. For Parts **III–VI** see *Ceram. Abs.*, **17** [4] 155 (1938). P.G.H.

Blue John Mine, Castleton. J. W. PUTTRELL. *Edgar Allen News*, **17** [194] 206–208 (1938).—P. describes the rare occurrence of a veined or banded type of fluorspar (calcium fluoride) which is of such fine quality and beauty that it is used for candelabra, vases, and other artistic and ornamental work. A local industry has been developed. M.H.

Catlinite and the Sioux quartzite. ERNEST L. BERG. *Amer. Mineralogist*, **23** [4] 259–68 (1938).—The Sioux quartzite at Pipestone, Minn., was originally an arkosic sandstone with interbedded argillaceous strata, some of which was very fine-grained. The catlinite bed represents the finest of these argillaceous layers. During consolidation or metamorphism, most of the catlinite bed was converted into secondary mica (sericite) and small amounts of free quartz. The catlinite shows neither secondary cleavage nor any evidence of recrystallization under dynamic metamorphism. Metamorphic agencies, probably hydrothermal, produced pyrophyllization of the quartzite beds and portions of the catlinite rock. Pyrophyllite probably replaced most of the quartz originally present in catlinite. Specularite was developed locally in pyrophyllitized pipestone. Near the surface of the outcrop and in the catlinite bed, exposed in the quarry, the pyrophyllite "appears" to have broken down, yielding diaspore and quartz. F.J.Z.

Ceramic raw materials of North Carolina. H. J. BRYSON. *Mfrs. Record*, **107** [5] 34 (1938).—The ceramic raw materials of N. C. are distributed principally throughout the western and Piedmont sections, although the eastern part contains numerous deposits of clay suitable for the manufacture of brick and tile. In addition to the deposits of feldspar, residual kaolin, magnesium talc, pyrophyllite, kyanite, and olivine, there are numerous deposits of sedimentary clays, spodumene, and volcanic ash. The location and description of the deposits are given. For use in the steel industry, olivine rock is quarried and cut into blocks 6 to 8 in. square and 12 to 16 in. long. The largest deposits of kyanite exist as schists in which the kyanite constitutes 10 to 40% of the rock mass. Spodumene, which may be substituted for feldspar in addition to being the main source of lithium, occurs in large accessible deposits. B.C.R.

Ceramic resources of the San Antonio, Texas, territory. ANON. *Mfrs. Record*, **105** [11] 70 (1936).—Large deposits of feldspar, comparable in quality to any in the U. S., flint, quartz, and silica sand are present. Laboratory tests indicate that many types of pottery, chinaware, porcelain, tile, and terra cotta can be made from the available raw materials. B.C.R.

Chemical studies on clayey weathering and kaolinization. ROBERT SCHWARZ. *Schriften königsberg. gelehrten Ges., Naturw. Klasse*, **13**, 13–26 (1936); *Chem. Abs.*, **32**, 2663 (1938).—While clayey weathering is a process especially of mechanical division and colloidalization of the mother rock, and the chemical reactions are confined to a hydrolytic cleavage under the formation of amorphous alumina-silicic acid gels, the kaolinization is a chemical reaction of the equation $K_2O \cdot Al_2O_3 \cdot 6SiO_2 + 7H_2O = Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O + 4H_2SiO_3 + 2KOH$. All hypotheses about the kaolinization remain uncertain as long as they are not based upon laboratory experiments. The latter show, in regard to various chemical and physical conditions investigated for feldspars and kaolin, that the transition of feldspar to kaolin is the result not only of an atmospheric weathering but also of increased temperature, increased pressure, and neutral to acid agents. Kaolin can be formed only under those conditions in which it is stable, *i.e.*, in neutral medium at temperatures up to 400° or in acid medium under pressure and between 200° and 400°; in very alkaline agents and under pressure, kaolin becomes converted into zeolites or permutites and in weak alkaline agents into montmorillonite ($Al_2O_3 \cdot 4SiO_2 \cdot H_2O$). It is necessary to distinguish clearly between clay and kaolin, because they are very different in their chemical and mineral composition and their genetic conditions.

Chemistry of the Trona process from the standpoint of the phase rule. W. A. GALE. *Ind. Eng. Chem.*, **30** [8] 867–71 (1938).—The Searles Lake system of salts and brine is regarded as having nine components, three degrees of freedom, and six solid phases. Equilibrium diagrams show the behavior of major components upon isothermal evaporation and illustrate the Trona process. At low temperatures the precipitation of the double salt glaserite [$K_3Na(SO_4)_2$] prevents a separation of potassium and sodium salts, whereas at high temperatures only sodium salts are precipitated. The hot concentrated liquid is removed and cooled rapidly to crystallize potassium chloride; at the same time supersaturation is maintained with respect to borax, which is crystallized before the mother liquor is returned to the cycle. Illustrated. F.G.H.

China clay as a filler in rubber compounding. T. L. GARNER. *Chem. Age* [London], **38** [985] 383 (1938).—The best (colloidal) china clay is a reinforcing filler, *i.e.*, it forms a bond with the rubber which is stronger than the matrix, but poorer quality clays are only diluents. China clay is also used as a base for organic colors. A.B.S.

Clay. WILLIAM BRAGG. *Proc. Roy. Inst. Gt. Brit.*, **30** (Part 1) [140] 39–67 (1938); see *Ceram. Abs.*, **17** [7] 261; [9] 313 (1938). G.M.H.

Composition and properties of clays. J. NAVARRO ALCÁCER. *Anales Soc. Espan. Fis. Quím.*, **35**, 269–84 (1937); *Chem. Abs.*, **32**, 4737 (1938).—Clays from various parts of Spain were analyzed for sand (SiO_2, feldspar), agglomerative substances, CaO, and Fe_2O_3, and granulating tests were made. Factors which could have an influence on permeability and mechanical resistance were given special attention. In coarse-grained clays, permeability diminishes appreciably with resistance in agglomerative substance. Determination of a coefficient of granulation as an index of the size of the clay particles gives, for coarse clays, an approximate idea of their permeability and per-

mits the determination of the highest or lowest sensitiveness of their mechanical resistance to various additions of agglomerative substances. With fine-grained clays, no appreciable variation is found. Study of volume density of clays is very useful. The behavior toward various additions of water permits prediction of variation in permeability, except for coarse and thin sands.

Copper industry of the U.S.S.R. ANON. *Bull. Imperial Inst.*, **36** [1] 52–60 (1938).—Exhaustive data are compiled regarding the copper situation in the Soviet Union, on which relatively little information is readily available to English or American readers. A.P.S.

Crystal structure of the clay minerals dickite, halloysite, and hydrated halloysite. STERLING B. HENDRICKS. *Amer. Mineralogist*, **23** [5] 294–301 (1938).—Dickite is shown to have an atomic arrangement based on space group C_s^4—Cc. Independent $[(OH)_4Si_2Al_2O_5]n$ layers are superimposed in some random manner in which a shift of $(2n + {}^1/_6)b_0$ of one layer with respect to another is preserved. Hydrated halloysite, $Al_2O_3 \cdot 2SiO_2 \cdot 4H_2O$, probably has a structure in which neutral $[(OH)_4Al_2Si_2O_5]n$ layers are interleaved with $[(H_2O)_2]n$ layers. F.J.Z.

Distribution of volcanic ash. KENNETH K. LANDES. *Bull. Amer. Ceram. Soc.*, **17** [8] 323–25 (1938).

Earth's interior, its nature and composition. L. H. ADAMS. *Sci. Monthly*, **44**, 199–209 (1937).—In the past few years the following definite developments regarding the earth's interior have been made: (1) precise measurement of the elastic constants of rocks and determination of the speeds with which elastic waves travel through them; (2) identification of the upper half of the crust as a granitic layer; (3) a demonstration that the core of the earth contains a heavy material such as iron; (4) an explanation of the two major discontinuities within the earth in terms of the elastic constants of typical rocks; (5) the supplying of strong evidence that large masses of iron may exist in the interior without influencing the earth's magnetic field; and (6) the establishment of an improved temperature-depth curve for the crust and the region immediately below it. H.E.S.

Economics of some of the less familiar elements. H. CONRAD MEYER. *Ind. Eng. Chem.*, **30** [4] 431–36 (1938).—The occurrence and commercial possibilities of the chief minerals containing beryllium, lithium, titanium, and zirconium are described, and their applications are discussed. Illustrated. F.G.H.

Experimental illustration of the spilite reaction. PENTTI ESKOLA, URHO VUORISTO, AND KALERVO RANKAMA. *Bull. comm. géol. Finlande*, No. 119, pp. 61–68 (1937); *Chem. Abs.*, **32**, 4914 (1938).—Anorthite heated in a steel bomb under water-vapor pressure with Na_2CO_3 and silica (quartz, or orthosilicate with excess CO_2 from $NaHCO_3$) was changed into albite-rich plagioclase. Pure albite was obtained only at the lower temperature (264° to 331°); experiments at 360° and up to 550° gave oligoclase or even andesine. Reaction and recrystallization were more nearly complete at temperatures below the critical point (310° to 330°). Because of poor crystallization at higher temperature, the results do not prove that mixtures containing anorthite are stable above 360°. Calcite and dolomite were formed when P_{CO_2} was not high. No zeolites were formed in any of the experiments (lowest temperature 250°). Albite invariably appeared between 250° and 335° in the presence of free silica or of CO_2 and olivine. Anorthite and olivine were changed into carbonates, which probably illustrates the carbonation process of silicate rocks observed in certain regions.

Geological reasons for the formation of the three natural aluminum hydroxides. JACQUES DE LAPPARENT. *Congr. Internat. Mines, Mét. Geol. Appl., 7th Session, Paris, 1935*, pp. 375–79; abstracted in *Chem. Zentr.*, **1938, i**, 2145–46.—Bauxites contain varied amounts of boehmite and diaspore, Al_2O_3, and gibbsite-hydrargillite, $Al(OH)_3$. One of the three minerals, however, is usually prevalent, so that bauxites can be grouped according to their main constituent as follows: (1) boehmite bauxite, which contains 90% boehmite and 1% SiO_2 (the remainder being composed of Fe_2O_3 and TiO_2), is found mostly under coal beds, and is a decomposition product of basalt; (2) gibbsite bauxite (usually pure), which originated from varied eruptive rocks; Fe, if present, is usually Fe_2O_3 or $Fe(OH)_3$, and SiO_2 is present as kaolinite; (3) diaspore bauxite, which contains some kaolinite, amesite $(SiO_2 \cdot Al_2O_3 \cdot 2[(Fe,Mg)O \cdot H_2O]$, and corundophilite $(3SiO_2 \cdot Al_2O_3 \cdot 6(Fe,Mg)O \cdot 5H_2O)$; Fe is chiefly present in the bivalent form. The crystallographic structure of the three hydroxides is as follows: (*a*) gibbsite (hydrargillite), Al''' and $3(OH)$; (*b*) boehmite, Al''', O'', and OH'; and (*c*) diaspore, a structure similar to that of BeO_4Al_2 (chrysoberyl) or SiO_4Mg (olivine), formed by complex $(H_2O_4)^{6-}$ and $2Al'''$ ions. Minerals accompanying diaspore bauxite can also be considered as complex $(H_2O_4)^{6-}$ ions: amesite as $(H_2O_4)Al_2 \cdot SiO_4Fe_2 + H_2O$ and corundophilite as $2[(H_2O_4)Al_2] \cdot 3[(SiO_4)Fe_2] + H_2O$. M.V.C.

Geology of the nonmetallics of the southeast. STEWART J. LLOYD. *Bull. Amer. Ceram. Soc.*, **17** [8] 325–26 (1938).

Geology of northern Ontario. H. C. RICKABY. *Eng. Jour.*, **21** [1] 20 (1938).—R. gives a brief account of the pre-Cambrian formations, which cover most of northern Ont., together with notes on the later rocks of southern Ont., whose history ended with the ice age of the Pleistocene. B.C.R.

Glass sands of Alabama. WALTER B. JONES. *Bull. Amer. Ceram. Soc.*, **17** [8] 327–28 (1938).

Indium. Occurrence, recovery, and uses. R. E. LAWRENCE AND L. R. WESTBROOK. *Ind. Eng. Chem.*, **30** [6] 611–14 (1938).—The available literature on the subject is reviewed, summarized on the basis of the authors' work on analysis and separation of the element from process residues. The history and occurrence of the element are dealt with briefly. The physical and chemical properties are compiled from a survey of the literature with careful selection of the most accurate values based on the latest information available. Proposed uses for indium are reviewed, including a number of recently patented applications. When added to glass mixtures containing sulfur compounds, indium oxide imparts a light yellow to dark yellow-amber color, depending on the amount of oxide used. One part oxide in two thousand parts is said to give a beautiful yellow color to the glass. F.G.H.

Industrial minerals of Canada in 1937. STAFF, DIVISION OF INDUSTRIAL MINERALS, BUREAU OF MINES, CANADIAN DEPT. MINES AND RESOURCES. *Can. Mining & Met. Bull.*, No. 313, pp. 260–78 (1938).—A brief discussion is given of asbestos, barite, bentonite, beryl, cement, ceramic products, chromite, diatomite, feldspar, fluorspar, garnet, granite, graphite, abrasive stones, gypsum, Fe oxides, lime, limestone, Li minerals, magnesite, $MgSO_4$, marble, mica, molding sand, nepheline syenite, phosphate, Ra and U, salt, SiO_2, Na_2CO_3, Na_2SO_4, S and pyrite, talc and soapstone, and whiting substitutes. A.H.E.

Lithium in New England. FRANK L. HESS AND OLIVER C. RALSTON. *Eng. Mining Jour.*, **139** [6] 48–49 (1938).—The spodumene deposits of Maine and Mass. are briefly surveyed. The manner of occurrence and the associated minerals are described. The extent of the deposit is given where this is known. To date, no important commercial use has been found for spodumene. The authors believe that it may soon find a more extensive market but fail to state where it will lie. Three photographs. J.L.G.

Location and distribution of the ceramic mineral deposits of North Carolina. A. F. GREAVES-WALKER AND S. G. RIGGS, JR. *Univ. N. C. Eng. Expt. Sta. Bull.*, No. 14, 60 pp. (1937); *Chem. Abs.*, **32**, 1417 (1938).

Magnesite mining and magnesite industry in Austria. H. STRAKELE. *Metallwirtschaft*, **17** [22] 605–607 (1938).—The extensive magnesite deposits in Carinthia, Styria, and the Tirol are described. Statistics on production and consumption are given. In 1936, 360,000 metric tons were produced which were chiefly exported to Germany, England, France, and the U.S.A. Next to those of the U.S.S.R., Austria's deposits are the largest. M.H.

Mineral deposits of Abyssinia. ANON. *Bull. Imperial Inst.*, **34** [2] 235–38 (1936).—Abyssinia is credited with great potential mineral wealth, but no authentic information of this is in existence. Gold, platinum, mica, potash,

coal, oil, gemstones, sulfur, silver, tin, tungsten, copper ore, iron, and manganese ore are known to occur. Bibliography. A.P.S.

Mineral resources of Johore (Malay). A. BEAN. Abstracted in *Bull. Imperial Inst.*, **34** [1] 54–57 (1936).—Tin, iron ore, wolframite, china clay, gold, and coal are the minerals available. More work will be required before the potential mineral resources of the State can be definitely stated. A.P.S.

Minerals from southern California. JOSEPH MURDOCH AND ROBERT W. WEBB. *Amer. Mineralogist*, **23** [5] 349–55 (1938). F.J.Z.

New Mexico sylvinite. Occurrence and mining. R. M. MAGRAW. *Ind. Eng. Chem.*, **30** [8] 861–64 (1938).—The mining operations of the Potash Co. of America are described in detail. Illustrated. F.G.H.

Occurrence of cristobalite in a sedimentary rock. D. S. BELYANKIN AND V. P. PETROV. *Amer. Mineralogist*, **23** [3] 153–55 (1938).—The mode of occurrence of cristobalite in the Nomanevi sedimentary rocks (western Georgia, U.S.S.R.) indicates secondary origin by means of a gradual cristobalization of primary quartz grains. F.J.Z.

Occurrence, crystal habit, and composition of uraninite from the Ruggles Mine, near Grafton Center, New Hampshire. B. M. SHAUB. *Amer. Mineralogist*, **23** [5] 334–41 (1938).—The Grafton Center uraninite is unique in occurring chiefly as a three-dimensional dendritic intergrowth with perthitic feldspar and also as skeleton crystals in the same material but more especially in albite intimately associated with the perthite. Individual crystals are associated chiefly with a granular albite intergrown with apatite and also occur sparingly within the feldspar. A new crystal form, trapezohedron (533), occurs on the uraninite associated with albite and apatite. Uraninite is composed chiefly of the oxides of uranium; the rare-earth and thorium contents are very low. The lead-uranium ratio is 0.041; this gives it an age of 304 millions of years, which is late Devonian. F.J.Z.

Origin of kernite and borax in the Kramer borate field, California. WALDEMAR T. SCHALLER. Presented at meeting of Mineralogical Society of America, Dec., 1935; abstracted in *Amer. Mineralogist*, **21**, 192 (1936).—The sodium borates (kernite and borax) of the Kramer borate field, Mohave Desert, Calif., lie from 350 to 800 ft. underground in bedded Tertiary clay deposits. The buried borate basin is about 4 miles long and 1 mile wide. The deposits of kernite and borax are about 100 ft. thick and consist of about 75% sodium borates. Ulexite and colemanite beds occur above and below the kernite and borax. In one mine, where the continuous and parallel clay layers are neither folded nor broken, borax is the only sodium borate present. In the other two mines, where the clay layers are folded and considerably broken, kernite is present, in millions of tons, in large and small crystals. In places, the clay beds have been pushed aside and molded around the kernite crystals. The kernite has formed from the borax by recrystallization due to increased temperature and pressure. The deposit is unusual in the absence of other saline minerals, such as the carbonate, chloride, and sulfate of sodium, calcium, and magnesium. A derivation of the borax from the change of ulexite to colemanite would yield borax free from these other saline minerals. The known extent of the ulexite-colemanite deposits is sufficient to furnish the known quantity of borax and kernite. F.J.Z.

Origin of the Quebec phlogopite-apatite deposits. KENNETH K. LANDES. *Amer. Mineralogist*, **23** [6] 359–90 (1938).—The theory of contact metamorphism that has been advanced to explain the origin of the phlogopite-apatite deposits of eastern Canada is untenable because of the cross-cutting relationship of the pyroxenite to the country rock. The theory advanced by L. as best fitting the observations made in the field and laboratory is that a granite pegmatite magma, unusually rich in phosphorus, became contaminated with dolomite or dolomitic limestone at much deeper levels than the present surface, where the temperatures were considerably higher. This contaminated magma moved upward into the rock now exposed and crystallized. Diopside (pyroxenite) was the earliest product followed by microcline and several associated minerals. Finally, aqueous solutions from the deeper crystallizing magma introduced a hydrothermal phase in the already stratified parts of the pegmatite, during which calcite, apatite-phlogopite, and many other minerals were deposited. F.J.Z.

Petrologic results of a study of minerals from Tertiary volcanic rocks of the San Juan region, Colorado. E. S. LARSEN, JOHN IRVING, F. A. GONYER, AND E. S. LARSEN, 3RD. *Amer. Mineralogist*, **23** [4] 227–57 (1938); see *Ceram. Abs.*, **16** [3] 98 (1937). F.J.Z.

Possible utilization of primitive trachyte in the ceramic industry. E. CREPAZ AND O. CENTANIN. *Chimica & Industria*, **20** [4] 199–200 (1938).—Experiments were made using the trachyte formation in the Verona and Padua districts for ceramic products. With an addition of 7.5% clay, a material was obtained which had the best resistance to concentrated acids and which also resisted alkalis well. The rock has a composition of 73.94 SiO_2, 14.03 Al_2O_3, 2.97 Fe_2O_3, 0.57 CaO, 0.21 MgO, 5.25 Na_2O, and 2.78% K_2O; 0.25% loss on ignition. Vitrification of the trachyte-clay mixture takes place between 1130° and 1180°C according to the clay content. The expansion coefficient of the material with 7.5% clay is about 4.1 to 4.5 $\times 10^{-6}$, compared with 3.8 for porcelain, 5 for molten basalt, and 4.5 to 4.9 for lime sand stone. The compressive strength is 2700 to 2800 kg./cm.^{2}. M.H.

Potash in the Permian Salt Basin. H. I. SMITH. *Ind. Eng. Chem.*, **30** [8] 854–60 (1938).—Potash was discovered in the brine of a well drilled for water in Texas in 1912. Nine years later the potash mineral, polyhalite, was identified in a well drilled for oil in Texas; 4 years later sylvite was discovered in a well drilled for oil in New Mexico. After the discovery of sylvite, a mineral containing approximately four times as much potash as polyhalite, active prospecting by core drilling was begun by both private and government agencies; production of sylvite on a commercial scale began in the U. S. early in 1931. Illustrated. F.G.H.

Potassium chloride from the brine of Searles Lake. R. W. MUMFORD. *Ind. Eng. Chem.*, **30** [8] 872–78 (1938).—The application of the Trona process to the production of potassium chloride at the plant of the American Potash & Chemical Corp. is described and illustrated. F.G.H.

Potassium salts as chemical raw materials. J. W. TURRENTINE. *Ind. Eng. Chem.*, **30** [8] 889–90 (1938).—The use of potassium compounds in ceramic industries is briefly reviewed. From the economic standpoint, T. suggests that the synthesization of a feldspar substitute from low-cost potash salts and cheap forms of alumina and silica be considered. The size of the potential market appears to justify a thorough survey of the possibilities of such a synthesis and substitution. F.G.H.

Production of potassium chloride in New Mexico. T. M. CRAMER. *Ind. Eng. Chem.*, **30** [8] 865–67 (1938).—Production methods and problems at the plant of the United States Potash Co. are described in detail. Illustrated. F.G.H.

Production, utilization, and marketing of columbite-tantalite minerals. ANON. *Bull. Imperial Inst.*, **34** [3] 348–53 (1936).—Australia is the principal producer of tantalite, and Nigeria, of columbite, which occurs with tinstone. Other deposits of columbite-tantalite minerals occur in the Union of South Africa, Southwest Africa, Uganda, India, Canada, Belgian Congo, and the U.S.A. Statistics concerning production and exports of these minerals and analyses of Australian, Nigerian, Uganda, South African, and U.S.A. ores are appended. Uses, market specifications, and prices are discussed. A.P.S.

Pseudowollastonite and wollastonite solid solutions with diopside and akermanite. J. F. SCHAIRER AND N. L. BOWEN. Presented at meeting of Mineralogical Society of America, Dec., 1935; abstracted in *Amer. Mineralogist*, **21**, 193 (1936).—Detailed laboratory studies of the systems $CaSiO_3$–$CaMgSi_2O_6$ and $CaSiO_3$–$Ca_2MgSi_2O_7$ show that both systems are binary. Wollastonite (β-$CaSiO_3$) forms

a series of solid solutions with diopside ($CaMgSi_2O_6$), extending to about 22% diopside. Pseudowollastonite (α-$CaSiO_3$) takes little, if any, diopside into solid solution. As a consequence of this difference in concentration of the solid solutions, the inversion wollastonite⇌pseudowollastonite is raised from about 1130° to 1368°C, and wollastonite solid solutions appear in equilibrium with liquid. The eutectic between pure diopside and wollastonite solid solution is at 1358°C and 62% diopside. The system $CaSiO_3$–$Ca_2MgSi_2O_7$ (akermanite) is of the simple eutectic type with no solid solution. There is a eutectic between α-$CaSiO_3$ and akermanite at 1398°C and 57% by weight akermanite. The inversion β-$CaSiO_3$ to α-$CaSiO_3$ is at about 1130°C for all compositions of this system, a reflection of the failure of solid solution of akermanite in both forms of $CaSiO_3$. F.J.Z.

Ratnagiri chromite deposit, Bombay Presidency. ANON. *Bull. Imperial Inst.*, **34** [3] 374–75 (1936).—Sixty miles from Ratnagiri, large outcrops of chromite occur associated with serpentine. Specimens assayed between 34 to 41.58% Cr_2O_3 and 25.26% FeO. At 1400°C powdered ore fused into a cake. A.P.S.

Sandstone-covered Missouri flint clay pit. W. D. KELLER. *Bull. Amer. Ceram. Soc.*, **17** [8] 322 (1938).

Talc, asbestos, serpentine, and kaolin in Ajmer-Merwara and its neighborhood. K. K. SEN GUPTA. *Quart. Jour. Geol., Mining, & Met. Soc. India*, **9** [1] 11–18 (1937).—All of the deposits described occur as alteration products of such basic igneous rocks as hornblende schists, hornblendites, amphibolites, and epidiorites. A.P.S.

Veatchite, a new calcium borate from Lang, California. GEORGE SWITZER. *Amer. Mineralogist*, **23** [6] 409–11 (1938).—The morphology, physical properties, X-ray measurements, and composition of veatchite, $Ca_2B_6O_{11}$·$2H_2O$, are presented. F.J.Z.

Zirconium compounds and their application in the refractory and ceramic industries. A. ESME. *Argile*, No. 178 [Feb.], pp. 11–15; No. 179, pp. 21–23; No. 181 [April], pp. 18–23 (1938).—E. gives a historical review of the discovery of zirconium metal. Zirconium is present in amorphous, crystalline, or graphitic form. It can be polished and drawn and has an atomic weight of 91.22, a specific gravity of 6.4, and a melting point of about 2350°C. Among its compounds, ZrO_2 is the natural form of zirconia and of baddeleyite and is of special interest. The hydrate, $Zr(OH)_4$, is amphoteric; it may form colloidal gels whose behavior is a function of the p_H. ZrH_4 and ZrH_2 burn in air when heated and yield a greenish flame rich in actinic rays. The sulfates, $Zr(SO_4)_2$, are either neutral or basic. Simple or complex fluorides yield a residue of anhydrous zirconia on heating. Carbides, ZrC_2 and ZrC, have a high melting point (2700° and 3000°C, respectively). The use of zirconium metal is discussed. Zirconia has a weak electrical conductivity, is a good thermal insulator, and is acid. Refractories with a pure zirconia base are very expensive. By treating a Zr mineral with HCl, however, products of high refractoriness may be obtained. In this manner, Coshet produced fusing cones withstanding 2200° and 2300°C. The HCl treatment eliminates iron and aluminum from the mineral. It is difficult to find a satisfactory bond for Zr refractories; the majority of the bonds used are too porous. In Germany a plastic mix is obtained by mixing ZrO_2 with salts of hydrolyzable zircon. Another solution is the use of ZrO_2 melted electrically, in the same way as silica; it can be mixed with the latter. Such products resist sharp temperature variations well. The introduction of ZrO_2 into porcelain bodies for laboratory ware greatly ameliorates their properties. Fused ZrO_2 has a high thermal resistance and a low coefficient of expansion and is very hard. A table shows the respective properties of silica, magnesite, clay, chromite, sillimanite, and zirconia. Methods for producing pure zirconia are discussed. The studies of Cohn (*Jour. Electrochem. Soc.*, Oct., 1935), F. Ebert and E. Cohn (*Ceram. Abs.*, **13** [7] 181 (1934)), and Coshet (XIII Congr. Chim. Ind.) are analyzed. Zirconia bestows brilliancy and opacity to enamel coats simultaneously. Zr enamels have a bluish tint. Zr is usually introduced into the enamel in the form of silicate. ZrO_2 ameliorates the properties of glass, particularly its chemical resistance; it also improves the elasticity of some soda-lime glasses. Deposits of zirconium and its mining are discussed in detail. See "Natural—," *Ceram. Abs.*, **17** [9] 313 (1938). M.V.C.

BOOK AND BULLETINS

California mineral production. HENRY H. SYMONS. *Calif. Dept. Natural Resources, Div. Mines, Tille Bull.*, No. 114, 199 pp. (1938); *Chem. Abs.*, **32**, 4481 (1938).—This annual statistical report contains detailed data on the amount and value of about 50 metallic and nonmetallic minerals, by substances and by counties.

Outline of the geological history of Hyderabad State with reference to its mineral resources. K. MIRZA. *Hyderabad Geol. Ser. Bull.*, No. 2, 58 pp. (1937). West End Printers, Secunderabad, India. Price 1 Re. M. summarizes the work of previous observers, the geological history of the state, and its mineral resources. The State possesses raw materials for the glassmaking, cement making, and ceramic industries. A.P.S.

Spectrum Analysis with the Carbon Arc Cathode Layer (Glimmschicht). LESTER W. STROCK. Preface by V. M. Goldschmidt. Adam Hilger, Ltd., London, 1936. 56 pp. Reviewed in *Bull. Imperial Inst.*, **34** [3] 434 (1936).—Minor chemical constituents of rocks and minerals are usually present in such small quantities that chemical methods have been largely supplanted by physical methods in their determination. The method of X-ray spectrum analysis invented by A. Hadding (Lund, Sweden) has given good service, but the cathode layer or "Glimmschicht" method developed by V. M. Goldschmidt and his co-workers at Göttingen possesses a high sensitivity which has made possible the discovery of many previously unknown associations of elements with one another or with certain minerals in nature. It is claimed that most elements can be determined in smaller quantities than by the spark or earlier arc methods. S. presents an authoritative and coherent summary of the method and of its application to geochemical problems. Illustrated. A.P.S.

PATENTS

Apparatus and method of boring into and treating earth material. LEO RANNEY. U. S. 2,126,576, Aug. 9, 1938 (June 7, 1935; Dec. 21, 1936).

Bentonite and sub-bentonite activation. ELMORE MCKELLAR (Elmore McKellar, R. R. Cooper, and G. M. Cairns). Can. 375,389, July 26, 1938 (Oct. 4, 1935). G.M H.

Process for concentrating oxidized ores by means of froth flotation. GRÉGOIRE GUTZEIT (Visura Treuhand Ges.). U. S. 2,125,631, Aug. 2, 1938 (Feb. 27, 1936).

Process of mineral concentration. F. X. TARTARON (Phosphate Recovery Corp.). U. S. 2,126,292, Aug. 9, 1938 (April 27, 1937). A process of concentration comprises admixing an ore with an insoluble and unsaponifiable oil and a sulfo-fatty-acid compound produced by the action of a sulfonating agent on a free unsaturated fatty acid of at least 12 carbon atoms and separating in an aqueous pulp the mineral values from the ore, the oil and sulfo-fatty-acid compound being used in relative amounts to cause them to conjointly effect collection of the values.

Treatment of beryllium ores or compounds. D. GARDNER. Brit. 488,383, July 20, 1938 (March 1, 1937).

Chemistry and Physics

Adsorption of weakly solvatized colloids on solid adsorbents: I, Adsorption of colloidal iron hydroxide on quartz. A. v. BUZÁGH AND E. KNEPPÓ. *Kolloid-Z.*, **82** [2] 150–58 (1938).—Colloidal $Fe(OH)_3$ was prepared by Graham's method, and its adsorption by batches of evenly dispersed quartz powders of different dispersities was studied. The amount of adsorbed material is not independent of sol concentration. The adsorption isotherms, in general,

were minimum-maximum curves; the type of isotherm was determined by the dispersity of the adsorbent. The cataphoretic migration speed of the sol particles and of the quartz particles was measured. The migration speed of the sol particles increased with sol concentration; the speed of quartz particles increased with sol concentration to a maximum and then declined. There appeared to be a relation between adsorption and capillary-electrical properties, *i.e.*, the maximum positive charge on the quartz particles corresponds to the minimum amount of adsorbed material. F.P.P.

Alkali estimation in silicates. D. JAPHE. *Sklářské Rozhledy*, **14**, 123–28 (1937).—A Lawrence Smith method simplified by W. Pukall (*Ceram. Abs.*, **12** [10–11] 401 (1933)) was used. Instead of the customary calcium carbonate and ammonium chloride mixture, a mixture of CaO and $CaCl_2 \cdot 2H_2O$ was used which decomposed the silicate more rapidly. A comparison of the results obtained by the rapid method with analyses by the standard Lawrence Smith method shows a maximum error of −1.2%. E.P.

Calculation of propagation velocities of elastic waves in crystals. E. GOENS. *Ann. Physik*, **29** [3–4] 279–85 (1937).—A theory is given and equations are derived for the tetragonal, hexagonal, and cubic systems. M.H.

Chemical analysis of refractory clays and a rapid method to determine their rational composition. E. DREXEL. *Rev. Matériaux Construction Trav. Publics*, No. 339, pp. 177–80B (1937).—D. simplifies the Kallauner-Matějka method (*Ceram. Abs.*, **10** [1] 68 (1931)). Examples are given. M.V.C.

Chemical determination of quartz (free silica) in dusts. EMANUEL KAPLAN. *Ind. Eng. Chem., Anal. Ed.*, **10** [7] 388 (1938).—In the Knopf method for the determination of quartz in the presence of silicates, the silicates are dissolved in hydrofluosilicic acid leaving behind a residue containing quartz. The acid, however, also decomposes quartz with a resulting average loss of 0.7%/day of the original weight of quartz present in the sample. The application of the frequently encountered compound interest law in the calculation of the amount of quartz originally present is described in detail. F.G.H.

Chemical and X-ray diffraction studies of calcium phosphates. HAROLD C. HODGE, MARIAN L. LEFEVRE, AND WILLIAM F. BALE. *Ind. Eng. Chem., Anal. Ed.*, **10** [3] 156–61 (1938).—Illustrated. F.G.H.

Colloidal properties of clays as related to their crystal structure. C. E. MARSHALL. *Jour. Phys. Chem.*, **41**, 935 (1937); see *Ceram. Abs.*, **15** [4] 131 (1936); **16** [11] 352 (1937). C.J.P.

Colorimetric determination of iron with salicylic acid. J. P. MEHLIG. *Ind. Eng. Chem., Anal. Ed.*, **10** [3] 136–39 (1938).—Illustrated. F.G.H.

Coprecipitation and p_H value of precipitations with 8-hydroxyquinoline. HARVEY V. MOYER AND WARD J. REMINGTON. *Ind. Eng. Chem., Anal. Ed.*, **10** [4] 212–13 (1938).—The separation of metals by the use of 8-hydroxyquinoline requires careful control of the p_H value during precipitation. If zinc is precipitated in the presence of magnesium, serious coprecipitation occurs unless the p_H value is kept at least two p_H units lower than the value at which magnesium alone is precipitated. The separation of ferric iron and aluminum is possible within narrow limits of hydrogen-ion concentration. Illustrated. F.G.H.

Determination of alkalis in silicates. D. JAPHE. *Sklářské Rozhledy*, **15**, 75–84 (1938).—The Pukall simplification of the Lawrence Smith process previously adapted by J. (see "Alkali—," this page), for which the maximum error was −1.2%, has been further modified so that in 6 hr. a rapid and comparatively accurate alkali estimation is possible, the greatest error being −0.3%. J. gives details of the determination of sodium as uranyl zinc sodium acetate in solutions of mixed alkalis. The time required is about 1½ hr. for the Na determination; in solutions of Na and K in the proportion 1 : 100 the error is ± 0.3%. Optimum solution concentrations are quoted. E.P.

Determination of the melting point of silicon. F. HOFFMANN AND A. SCHULZE. *Metallwirtschaft*, **17** [1] 3–6 (1938).—The melting point of 99.89% pure Si was found, thermoelectrically and optically pyrometrically, to be at 1410 ± 2°C; that of commercial Si of 98% purity is 2° lower. M.H.

Determination of sulfur in oil. Tetrahydroxyquinone as an indicator in direct titration. ROBERT T. SHEEN AND H. LEWIS KAHLER. *Ind. Eng. Chem., Anal. Ed.*, **10** [4] 206–207 (1938). F.G.H.

Dual character of light. S. M. SULAIMAN. *Proc. Indian Sci. Congr., 25th Congr.*, **1938**, Part 3, p. 6.—If a light corpuscle were a binary system, consisting of two components of equal and opposite charges rotating around each other and moving forward along their axis of symmetry, it would be an electromagnetic phenomenon subject to Maxwell's equations. The electromagnetic field will be both created and carried along by the system. In the transverse section the motion will be periodic. By the use of cylindrical coordinates it can be shown that the system will be propagated with the characteristic velocity $\frac{c}{\sqrt{\mu\kappa}}$ of the medium which will be its phase velocity as well. Such a rotating system, moving along the Z axis and possessing both (1) momentum in the direction of Z, and (2) a transverse periodic motion, would exhibit both the particle and the wave aspects simultaneously, according to whether the effect is observed longitudinally or transversely, thus showing the dual character of the light. A.P.S.

Estimation of boron by a modified flame test. H. C. WEBER AND R. D. JACOBSON. *Ind. Eng. Chem., Anal. Ed.*, **10** [5] 273 (1938).—A modification of the flame test is presented, in which concentrated sulfuric acid and methyl alcohol produce a volatile boron compound. Even with glasses containing less than 1% of boric oxide, checks of 10% or better may be expected. Illustrated. F.G.H.

Gravimetric determination of zinc by the mercuric thiocyanate method. W. C. VOSBURGH, GERALD COOPER, WILLIAM J. CLAYTON, AND HARRY PFANN. *Ind. Eng. Chem., Anal. Ed.*, **10** [7] 393–94 (1938).—Details of the technique are described, and some of the sources of error are discussed. F.G.H.

Measurement of components of thin sections with the planimeter. G. EVERETT MARSH. *Amer. Mineralogist*, **23** [6] 412–13 (1938). F.J.Z.

Observations on the rare earths. Quantitative estimation by means of their arc spectra. C. N. MCCARTY, L. R. SCRIBNER, AND MARGARET LAWRENZ WITH B. S. HOPKINS. *Ind. Eng. Chem., Anal. Ed.*, **10** [4] 184–87 (1938).—The determination of some individual rare earths in complex rare-earth mixtures by means of the Hilger EI quartz-type spectrograph, using an internal standard, has been studied. The percentages of individual rare earths present in the ores were found to vary both with the type of ore and with its geographic origin. The method was applied to the determination of individual rare earths in an artificial mixture of rare-earth oxides of known composition. The maximum error as calculated from the results was found to be ± 15%. F.G.H.

Potentiometric titration of aluminum solutions containing nitrates with the antimony electrode. K. L. MADZHAGALADZE. *Zavodskaya Lab.*, **6**, 305–308 (1937).—After the decomposition of Al ores by HNO_3, the Al and free HNO_3 can be determined by potentiometric titration with 0.5 *N* KOH. In the presence of a maximum of 8% Fe there is no difficulty in determining when the HNO_3 is neutralized, but an allowance must be made for KOH required to react with the ferric iron. P.B. & E.S.

Reactions in the solid state: I, Reactions between barium carbonate and ferric oxide in the presence of oxygen. ROLAND WARD AND JAMES D. STRUTHERS. *Jour. Amer. Chem. Soc.*, **59** [10] 1849–54 (1938).—The reaction between barium carbonate and ferric oxide in the presence of oxygen was studied at temperatures ranging from 610° to 970°C. Reaction rates were measured at 610°, 754°, 775°, 808°, 835°, 880°, and 970°C. From these reaction rates the heat of activation (q) of the barium carbonate was calculated. The value for q below the transition temperature is 25,000 cal./mole and above the transition temperature, 19,000 cal./mole. The mechanism is shown

to be one of diffusion of barium carbonate through the reaction product. A method is proposed for distinguishing between a reaction controlled by diffusion rate and one controlled by transition rate. Oxidized compounds of iron are produced by the oxidation of the ferrites at temperatures above 700°C. The most favorable temperature for their production lies between 835° and 880°C; this is above the reported stability range of barium perferrite. No peroxide formation could be detected in any of the reaction products. Illustrated. F.G.H.

Separation of calcium as sulfate by precipitation in concentrated methanol solution. Application to the analysis of magnesite and technical magnesium oxide. EARLE R. CALEY AND PHILIP J. ELVING. *Ind. Eng. Chem., Anal. Ed.*, **10** [5] 264–69 (1938).—The method is especially convenient for the rapid determination of calcium in magnesite and in technical grades of magnesium oxide. It is less satisfactory for the determination of high percentages of calcium, such as are found in limestone. F.G.H.

Structure of zirconium silicide, $ZrSi_2$. ST. V. NÁRAY-SZABÓ. *Z. Krist.*, **97**, 223–28 (1937).—A new structure at variance with that of Seyfarth (*Ibid.*, **67**, 294 (1928)) was determined; it has a unit cell with the dimensions a = 3.72Å, b = 14.61Å, c = 3.67Å, space group D_{2h}^{17} with 4 molecules to the unit cell. $ZrSi_2$ has an atomic layer structure. H.I.

Tetrametaphosphate of sodium. A. BOULLÉ. *Compt. Rend.*, **206** [23] 1732–33 (1938).—Anhydrous tetraphosphate of sodium, when heated to 410°C, is transformed irreversibly into the insoluble metaphosphate. Above 410°, this latter substance is not stable and forms trimetaphosphate. M.H.

PATENTS

Beryllium compounds. SERI HOLDING (SOC. ANON.). Fr. 822,829, Jan. 8, 1938; *Chem. Abs.*, **32**, 5165 (1938).—Soluble Be compounds are prepared from ores containing Be, particularly silicate ores such as beryl, by causing an anhydrous oxide, hydrate, carbonate, or bicarbonate of an alkali or alkaline-earth metal to act on the ore to bind the SiO_2 of the ore as a silicate of such metal at 600° to 1200° but not high enough to fuse the mass and afterward lixiviating with a boiling solution of CaO to form an insoluble silicate which separates, leaving the Be oxide in solution. The oxide is converted to carbonate by treatment with CO_2.

Dense soda ash manufacture. P. A. KEENE AND A. P. JULIEN (Solvay Process Co.). Can. 374,900, July 5, 1938 (May 5, 1936; in U. S., May 7, 1935). G.M.H.

Manufacturing solid sodium aluminate. PENNSYLVANIA SALT MFG. CO. Ger. 657,206, Feb. 10, 1938 (Dec. 7, 1934); VI*b*/12*m*. 5. Solid sodium aluminate is made by reacting alumina hydrate and caustic soda. Pulverized alumina hydrate and solid caustic soda are mixed together in the presence of just enough water to dissolve the soda, and the mixture of solid material is transformed at a temperature not exceeding the melting point of NaOH. D.A.B.

Oxidation of titanous salts. C. R. HAGER (E. I. du Pont de Nemours & Co.). U. S. 2,125,340, Aug. 2, 1938 (Jan. 9, 1936).

Process for manufacture of alkali metal beryllium fluorides. GUSTAV JAEGER (Deutsche Gold- und Silber Scheideanstalt vorm. Roessler). U. S. 2,125,026, July 26, 1938 (June 10, 1937). A process for the direct and dry manufacture of completely water-soluble alkali metal beryllium fluorides comprises heating a mixture of a material selected from the group consisting of beryllium oxide and beryllium hydroxide with an acid alkali metal fluoride to temperatures ranging from 100° to 300°C.

White oxide of tin. GEORGES ANDRÉ FAVRE. Fr. 820,170, Nov. 5, 1937; *Chem. Abs.*, **32**, 5589 (1938).—Sublimed SnO_2 is obtained directly by heating pure dry spongy Sn, in which H has been adsorbed, in an atmosphere of 0° to about 300°.

General

Aspects of the ceramic industry. WILFRED GILBERT. *Trans. Mining, Geol., & Met. Inst. India*, **33** [4] 375–437 (1938).—G. suggests that the progress of the ceramic industry is being quickened by modern technology which largely depends on help from the geologist and the petrologist who can enter into any new activity at the beginning, when the raw materials are being studied, and at the end, when the fired products are being examined. The subjects treated are as follows: (1) Ceramic raw materials. (2) Method of chemical analysis of ceramic raw materials. G. outlines a modified method of Seger's rational analysis evolved by him, which falls into two sections, (*a*) a determination of the total alkalis by the Lawrence Smith method and (*b*) a separation of clay substance and mica from feldspar and quartz by solution in boiling sulfuric acid. (3) Mineralogical composition. After the ultimate analysis has been made by the rational method, G. outlines a method for calculating the mineralogical composition. (4) Colloidal characteristics of clays. (5) Casting process in ceramics. (6) Ceramic materials used in the electrical industry and properties required. G. deals exhaustively with electrical porcelain in the development of which the geologist plays a large part. The correct quality of soapstone is necessary to manufacture materials of low dielectrical losses for high-frequency work; the use of the correct grade of titanium dioxide for high dielectric constant condensers is dependent on his initial labors. (7) General survey of the refractories industry: (*a*) tests made on refractory materials, (*b*) miscellaneous refractories. The modern refractories industry is continually being asked for materials of higher resistance to heat; longer life is demanded to reduce the periods of shutdown, and increased resistance to slag attack is required. This has resulted in rigid specifications and much scientific study of fundamentals. (8) Slag action and relative ceramic processes. Much greater attention must be given by suppliers of coal to the exclusion of undesirable material, especially since the development of pulverized fuel firing, where small quantities of dyke rock or other fusible materials in coal rapidly corrode an expensive refractory lining by forming low-melting compounds; the ash of the clean coal may be much more refractory. (9) Recent work on structure—points revealed by X-ray study. Recent work has indicated that the crystal structures of the silicates are dependent on the silicon-oxygen and aluminum-oxygen complexes. G.'s work in India is the manufacture of high-grade aluminous refractories containing a high percentage of mullite. The Indian bauxites which are sometimes used as the basis for the high alumina content are extremely porous and after the necessary adjustment of composition, the material is in a state suitable for the manufacture of mullite refractories. The porous nature of the Indian bauxites allows penetration of the fluid materials and gives a large reacting surface. G. believes that the drawback to the more extensive use of kyanite, sillimanite, and corundum in refractories is that they lack porosity so that their action is very slow (unless high firing temperatures are used), as the fusible material can not readily penetrate and encourage the formation of mullite; true mullite development comes only after some preliminary fusion. It is interesting to note that mullite has an incongruous melting point and breaks down into corundum and siliceous glass at 1810°C. A.P.S.

Edward M. Ayers, pioneer in silica sand business. ANON. *Bull. Amer. Ceram. Soc.*, **17** [8] 350 (1938).

Contributions of Mellon Institute to the advancement of science, a national asset. K. T. COMPTON. *Sci. Monthly*, **45**, 97–100 (1937).—In Mellon Institute scientific discoveries may be examined and developed for their possible industrial value; the technical troubles of industry may be cured and its ambitions for new and better products or methods realized with the aid of science. The Institute is also a training ground and recruiting center for applied

scientists who will later be absorbed into industrial organizations. It provides the facilities of a research laboratory to the thousands of industrial units which are not able to justify the establishment of private research laboratories. In many cases, it demonstrates to an industry the advantage of creating its own permanent laboratory. H.E.S.

Determining the swelling of clay. F. F. LAPTEV AND A. G. KIR'YANOVA. *Pochvovedenie*, **32**, 259–66 (in English 267) (1937); *Chem. Abs.*, **32**, 23 (1938).—Clay is ground to pass a 1-mm. sieve and moistened to a workable consistency, and 3- x 2-cm. molds are made. After drying, the clay form is covered with a rubber membrane and weighed in water to establish the volume of the dry sample; the top of the closed membrane is pierced with pinholes, and the whole is immersed in water or in any solution. The sample is kept under water for 10 days and weighed in air and in water. The increase in volume (swelling) is calculated in percentage of the volume of the air-dry clay.

Difficulties in the administration of silicosis compensation. ANON. *Eng. News-Record*, **120** [1] 22 (1938).—The administration of the silicosis compensation acts in Wisconsin is discussed. Wisconsin has recognized the disease as compensable since 1919. As silicosis develops slowly over the years during which a worker is exposed to the silica dust and death does not usually result from silicosis but from tuberculosis or pneumonia (which is contracted due to the resulting weakness of the lungs), the problem of compensating workers is difficult. In addition, the afflicted worker may have changed jobs several times before being disabled, possibly to one in which silica dust was not present. This situation frequently brought forth the question as to which employer should be liable for compensation. The Supreme Court of Wisconsin has decided that a disabled employee can not obtain compensation from an employer when not subjected to silica dust nor may he bring a claim against a former employer since he had not become disabled while working there. Several amendments have been passed to correct this situation, although several of them have been subsequently declared invalid. One concern has solved its problem by shifting employees who have contracted the disease but are not disabled to other occupations. B.C.R.

Dust collection in potteries. ANON. *Pottery & Glass Record*, **20** [7] 181 (1938).—A new method of dust collection by means of a mist or froth is described. Units sufficiently small to serve 3 to 6 operatives can be used, and much overhead ducting and housing equipment can be saved. Each unit occupies a space of 2 x 3 ft. and requires a $1^1/_4$-h.p. motor and a gallon of water a day. It must be cleaned (5 min.) once a week. A.B.S.

Dust hazard in industry. E. L. MIDDLETON. *Trans. Ceram. Soc.*, **37** [5] 190–208 (1938).—M. discusses the industries in which silicosis may occur and its prevention and describes the action of silica dusts on the human system. See "Industrial—," *Ceram. Abs.*, **16** [4] 138 (1937). R.A.H.

Forecast of technological education. K. T. COMPTON. *Sci. Monthly*, **45**, 357–60 (1937).—C. believes that technological education in the future will show the following characteristics: (1) The importance of technological education will continually increase. (2) There will be increasing differentiation between technological and technical training, *i.e.*, between the engineering school and the trade school. (3) Large industrial units or associations will establish their own trade schools to train expert technicians for special purposes. (4) Undergraduate curriculums in technological schools will avoid specialization except in rather general fields and will devote increasing attention to physics, chemistry, and the general principles and methods of engineering. (5) As a corollary, the need for many technological specialists will be met by graduate curriculums. (6) There will be increasing differentiation in scope and more logical adaptation to environment in colleges and universities. (7) Research will become a more important activity in the leading technological schools. H.E.S.

International chemistry meetings. ALEXANDER SILVERMAN. *Bull. Amer. Ceram. Soc.*, **17** [8] 348–49 (1938).

Passing of a great man. ANON. *Refrac. Jour.*, **14** [6] 348 (1938).—A brief biography of J. W. Mellor, including tributes from the leading British ceramists, is presented. See *Bull. Amer. Ceram. Soc.*, **17** [6] 278–83 (1938). B.C.R.

Science in an American program for social progress. K. T. COMPTON. *Sci. Monthly*, **44**, 5–12 (1937).—Science may be made more effective in the American program for social progress by adequate dissemination and correlation of scientific information regarding the materials and forces with which great groups of the population have to deal, the application of greater scientific research in industry, and the extension and encouragement of scientific training in educational institutions. Scientific developments in new fields are (1) development of new industrial uses for farm products, (2) improvement of transmission and utilization of electric power, (3) great developments in materials and methods of building construction, and (4) a new era in biological discovery and physical science. H.E.S.

Frank Jerome Tone. ANON. *Bull. Amer. Ceram. Soc.*, **17** [8] 333–34 (1938).

Utilization of fluid mud in coal mines. C. S. FOX. *Trans. Mining, Geol., & Met. Inst. India*, **33** [2] 170–74 (1937).—F. suggests that fluid mud may be used for extinguishing coal-mine fires, for the preparation of comparatively dust-free zones in mine workings, for the separation of coal from shale in circumstances where the extra expense would be warranted, and in hydraulic conveyance of sand for stowing. A.P.S.

BULLETIN

Use and Care of Respirators. ANON. *Bull. Air Hygiene Foundation;* abstracted in *Mining Jour.*, **22** [1] 40 (1938).—The general system of respirator maintenance, embracing individual maintenance and central maintenance, is discussed. The latter is favored. Respirator maintenance usually consists of cleaning, sterilizing, and repairing. Cleaning is done by washing with brush and soap in warm water. Directions and formulas for sterilizing respirators in chemical solutions are also given, with instructions for the care and cleaning of the filters which must be removed before cleaning or sterilization. P.G.H.

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